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Katanga and Its Mineral Development

By Owen Letcher

The Later Story of the New Cornelia

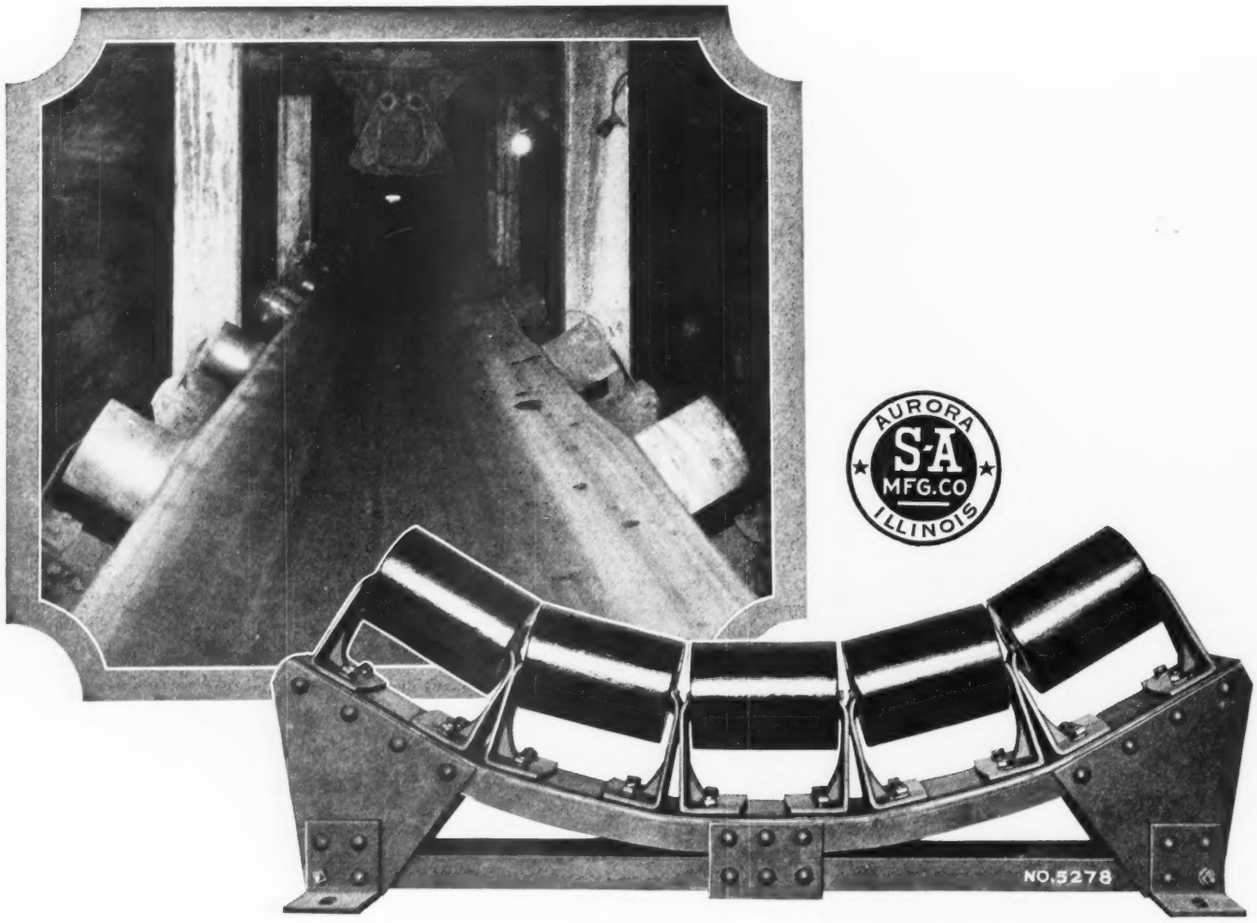
By T. A. Rickard

Smelter and Refinery of the Nichols Copper Co.

By Edward H. Robie

Survey Explorations Above the Arctic Circle

The largest single deposit of copper ore developed in the Belgian Congo by Union Minière du Haut-Katanga



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ENGINEERING AND
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JOSIAH EDWARD SPURR, Editor

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Rise of South African Copper

SOUTH AFRICA became a producer of gold in 1884; in 1905 it passed the United States and became the premier gold-producing country in the world. Since then no rival has threatened to displace it, and the production for 1924, valued at about $200,000,000, was well over half the world's total. Will history repeat itself in the case of copper? Speaking geographically rather than politically, so as to include Rhodesia and the Belgian Congo, South Africa's rise in the copper world has been phenomenal. The production for 1924 was about 195,000,000 lb., or nearly 7 per cent of the world's total, as against about 2½ per cent in 1918. Although contributions to African copper production have been made by the Messina Development Co., Falcon Mines, Ltd., and others, the outstanding producer is the Union Minière, operating in the Katanga; and the statistics reflect its increased output. Beginning with about 2,000,000 lb. in 1911, the figures show a progressive increase—except for an interval after the war—up to nearly 189,000,000 lb. in 1924. The greatest single stride is the last, 1924 exceeding 1923 by 62,000,000 lb.

Although the Union Minière is the only actual producer in the vast copper belt near the Congo-Rhodesian border, a number of promising deposits have been located and systematic search of immense concessions in Northern Rhodesia is being conducted by a number of well-financed British companies.

Thus far nothing approaching the Union Minière enterprise in the size and richness of the orebodies developed has been revealed. In fact, the only measurable deposits appear to be those of the Bwana M'Kubwa Copper Mining Co. At the M'Kubwa mine, 4,592,000 tons of 3.63 per cent ore in massive deposits has been developed, and at the N'Kana mine something less than 1,000,000 tons of 3.48 per cent ore is estimated. Here, work has been suspended without by any means exhausting the possibilities.

The Rhodesian Congo Border Concessions has the mineral rights on 52,000 square miles in Northern Rhodesia on which a number of widely separated but promising areas are being prospected. On at least one of these the existence of a workable orebody has, according to trustworthy information, been established definitely. This is known as the N'Changa area, situated only about 15 miles from a point on the Northern Rhodesia railroad lying between Bwana M'Kubwa and Elisabethville, the center of the Union Minière activities. Still another development company is the Rhodesia Mineral Concession, Ltd., which has a 7,000-square-mile concession farther south.

Bwana M'Kubwa has been amply financed by a group of London "houses," and a leaching plant designed to treat 1,000 tons of ore per day is to be erected at once, according to present plans. None of the other projects has advanced to the stage where metallurgical plants are to be given serious consideration.

Some idea of the size and complexity of the project of developing and equipping a property in this remote part of the world can be gained by reading the excellent article by Owen Letcher on the Union Minière enterprise that begins on page 277 of this issue. It is significant, also, that the cost of production is around 10c. per pound even when ore ranging from 6 to 16 per cent copper is mined and when the rate of output is 15,000,000 lb. per month. Of course, the pioneering done by the Belgian company will help the new companies that may enter the field. Nevertheless, the process of converting an ore deposit into a producing mine is unusually tedious and costly—more so even than in South America, where the mines are comparatively near to seaports.

On the other hand, in considering the potentialities of the region, the great size of the indicated copper-bearing area is important. The Union Minière itself works a number of widely separated deposits, the Star of the Congo and the Kambove mines being almost 100 miles apart. Bwana M'Kubwa, though near the Minière concession, is more than 100 miles from the Star of the Congo in the opposite direction from Kambove. Reported discoveries on the Rhodesian Congo Border concession are more than 300 miles apart. As the crow flies it is only about 300 miles from Nacozari, Mexico, to Jerome, Ariz., and between these—without crowding one another—are Cananea, Bisbee, Ray, Ajo, Clifton-Morenci, Miami, Superior, and Globe, than which no more productive copper region has ever yet been found.

Clearly there is plenty of room in the South African "copper country" for many large mines. That one company at least possesses the largest proved reserve of high-grade copper ore ever developed is beyond dispute. It is more than likely that other rich deposits will be opened by the Union Minière on its big concession; and other profitable copper enterprises may be established. The Union Minière may some day become the largest producer in the world. But, granting all this, development by other companies is much too meager to indicate the ascendency of South Africa's copper star over that of Arizona, or even of South America.

Aluminum and Competition

THAT the Aluminum Company of America dominates the aluminum industry in the United States is too well known to cause any comment. That it is pace-maker for the producers abroad in the markets of the world has also been commonly taken for granted. But that it actually controls the bulk of foreign production as well as the domestic output has never been definitely stated by an official of the company, so far as we know. Rumors that this is the case, however, are gaining increasing circulation, it

being said that the company controls as much as 95 per cent of the world production.

Such a commanding position abroad could have been reached only through acquiring a controlling interest in the British, French, and Swiss branches of the industry, to say nothing of the German. If this has been accomplished, it is a notable achievement, for it would hardly be supposed that, with the experiences of the war so fresh in mind, any of the European nations would allow control of an important industry to pass into foreign hands.

How the Aluminum Company has averted competition at home is readily understood. To make aluminum, bauxite is necessary, and the company is believed to own practically all the deposits at home and anything abroad that might otherwise fall into the hands of a possible American competition. Its resources of bauxite are large—ample for many years to come, it is said—a hundred years' supply, it has been estimated, even allowing for an increasing consumption rate.

Nevertheless, competition is to be attempted, it seems. Only recently a company was organized in the Province of Quebec for the purpose of engaging in the production of aluminum. Who the interests behind this company are does not appear in its list of officers and directors. Equally lacking is any information as to where the company expects to draw its supply of ore. It is known, though, that the Duke interests, of tobacco fame, have considered in the past the possibility of entering upon the production of aluminum, using possibly Saguenay power for the purpose, and it is said that recently they have again given the matter consideration. It will be interesting to watch developments.

Metallurgy as a Cause of Low Prices

A PROMINENT MINING ENGINEER in conversation recently said he believed that the present somewhat permanently subdued condition of the copper industry was due to the progress in the treatment of ores. The advance in metallurgy, he pointed out, had rendered available for the market great quantities of ores hitherto unavailable: with the result of a somewhat redundant supply.

This is certainly one of the important factors in the present situation. However, it is the fact that it operates in two ways. It not only increases the supply of copper, but it increases economy, makes use of waste, and cuts cost. Not only do improved metallurgical processes put on the market great supplies of copper from a hitherto almost worthless mine, like the New Cornelia; but they increase recovery in an ore like that of the Lake Superior region, make the utilization of the reduced grade possible, and enable a reworking of enormous quantities of discarded tailings, and so prolong indefinitely the life of a great mine like the Calumet & Hecla, which would otherwise be paralyzed by competition. Of course all these things tend to keep the price of copper down, so that from the standpoint of the operator and copper dealer the case about balances—he produces more ore at a less cost, but gets a correspondingly lower price.

In the end, as we know, the invention and application of labor-saving and production processes must benefit everybody. The indignation of the farmers in England when labor-saving machinery was invented no longer finds any sympathy among laborers. Miners are not lower paid because they drill by machine instead of by hand; they are paid more, because they are more productive and earn more. The reasonable price of copper, although not looked upon with great enthusiasm by our industry, tends to maintain copper in favor, in face of the competition of other metals and materials. The problem, indeed, is to produce copper cheaply and sell it cheaply, but at a profit: the final profit must come from wide use and large sales, rather than from a large margin per pound.

Of course, in the case of copper, an equally important factor in producing the present overabundant supply is the geological circumstance of the existence of great bodies of easily accessible and cheaply mined ores which lay ready for the improved metallurgical and mining methods to work upon. As in the course of decades these are worked out, new problems will come up.

In the case of lead and zinc, no low-grade orebodies analogous to the disseminated copper deposits are known; hence the relative scarcity of these metals. With the naturally resultant higher prices, metallurgical processes will render a great quantity of these metals available which is now unusable because in the form of complex sulphide ores. Nevertheless, it is difficult to see how developments will ever parallel those in the copper industry, from the lack of known similar extensive orebodies. It is, of course, conceivable that careful examination may reveal surprises in that direction. The amount of low-grade lead and zinc ores in the Missouri-Oklahoma-Kansas region, for example, is reported to be enormous; and it is said that sustained high prices for these metals would result in an abundant and continued flow. Indeed, if and when lead and zinc prices rise so that it is profitable, by large-scale methods, to mine ores containing the same tenor of metal as have copper ores that are currently mined, it is likely that the response of the earth will be astonishing. And this is what will take place unless new districts of rich lead ores are discovered.

Fake Assays and Assayers

OUR ATTENTION was directed recently to a suit for damages brought against one assayer by another. The defendant sought to expose the dishonest practice of the plaintiff, who reported the presence of values in samples which other assayers reported as of no commercial value. The defendant's purpose is a commendable one, but the intricacies of the law are such as needlessly to harry him and subject him to unnecessary expense for his public spirit.

We have before us two assay certificates signed by the plaintiff, in one of which he reports that the "ore sample" contained $6.18 by cyanide test, and by fire assay, $4.12 value per ton. This on its face proves incompetence, or ignorance, or dishonesty. A valueless sample was crushed and divided and one part submitted to the plaintiff and the other to a well-known firm of assayers. The plaintiff reported $6.18 value in gold per ton and the other assayer, a trace of gold. The plaintiff in question is also listed in the U. S. Bureau of Mines Serial 2496 as one of those assayers who reported platinum in various samples in which the Bureau's chemists were unable to find any. He is thus proved guilty of issuing misleading reports.

Fake assays by fake assayers have long been known

in the mining industry. The fake assayer crops up at intervals, and when he is discredited moves on to some new locality. Certain Western mining centers have been afflicted with a species of faker who has reported to his clients fraudulent tin and platinum assays, deriving a few paltry dollars from the unwary and being responsible for the expenditure of money in purposeless prospecting by his victims. The unsuspecting victim of this vicious practice continues to send his samples to the "assayer," who always finds "values," until he is no longer financially able to keep up with the game or becomes suspicious. It is a pitifully small knavery, akin to the other variety of leech, the assayer who buys stolen gold. It is difficult to convict these men in the ordinary courts. Whether some system of registration would be practicable to control this situation is worth considering. The California legislature has now under consideration a bill requiring the licensing of all ore and bullion buyers in the state. This deserves to pass, for something of this kind is necessary to control the theft of gold and amalgam, which has reached serious proportions. A similar enactment might be useful in preventing an assayer from doing business after fraud has been proved.

End of the Gold Premium

THE RESUMPTION OF GOLD PAYMENTS in South Africa and the consequent return of that great gold-producing country to the gold standard are assured by a recent official announcement of the South African authorities to the effect that the resumption of gold payments will not be postponed beyond June 30 next. In other words, specie payments will be resumed after that date. This means, of course, that the gold premium, which has been of such great value to the Rand miner, will become negligible in amount, as it is at present, for the gold premium can be obtained only in countries which are off the gold standard. South Africa, Australia, Canada and India have been in this class; gold producers in each have received gold premiums of varying amounts, depending upon the depreciation of their respective currencies.

The gold premium has been dwindling of late in South Africa and Australia owing primarily to the improvement in sterling exchange, and their own currencies coincident with it, so that the ultimate disappearance of the gold premium has been anticipated for months. In fact, there is a strong possibility that it may vanish before the official date set, for the reason that sterling exchange appears likely to return to par before next June. Although Australia is expected to return to the gold standard soon, no official announcement of the attitude of the Australian Government has been made.

The dwindling of the gold premium and its final abolition will show in the earning statements and balance sheets of the Rand gold-mining companies. Whatever compensation they may lose in the form of increased revenue from a gold premium will be more than offset by the return of the British Empire to the gold standard. The benefits of a gold premium are transitory at best, and to be most effective depend on a declining currency. When currencies are stable, price relations between various countries become adjusted and the premium loses it value. With the two great English-speaking nations on the gold standard, Germany and various smaller countries back, and others on the way, the gold miner will have no occasion to fear the idle talk about repudiation of the gold standard and the demonetization of gold.

Open House at the Nichols Copper Works

NEXT WEEK those attending the annual meeting of the American Institute of Mining and Metallurgical Engineers will have an opportunity to visit one of the oldest electrolytic refineries in the world, that of the Nichols Copper Co., on Long Island. In this issue we publish—pages 290-295—a description of this plant, that we trust will prove a handy guide to the Institute visitors as well as being of interest to metallurgists who are not able to be here, but who are interested in copper smelting and refining.

Of chief interest is the method of refining, this being one of the two plants in the world using the series rather than the multiple system. Most of those who have had to do with the design of electrolytic refineries seem to have given little thought to series treatment; the multiple system has been installed as a matter of course. But improvements have been made, and more will no doubt follow, which will keep the series process in the running, and metallurgists can gain a great deal by a study of the methods pursued at Laurel Hill.

Fortunately for all concerned, Mr. C. W. Nichols, president of the Nichols Copper Co., has extended this invitation to Institute visitors and consented to publishing a description of the plant. In so doing, he dispels the reputation that the company had for keeping somewhat to itself, and joins the vast majority of metallurgical plants in the Americas who have outlived the age of metallurgical mysticism. When the staff of the Nichols Copper Co. go visiting they will find themselves welcome at other plants, so this free interchange of operating data and helpful comment will benefit all.

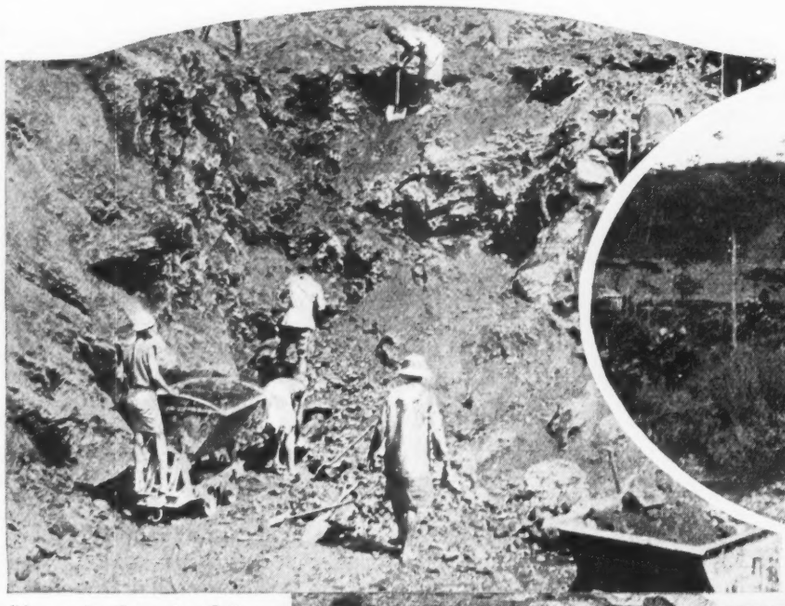
Bootlegging and the Mining Camp

THE COLORADO FUEL & IRON CO. announces that in the future any employee found making, selling, or distributing intoxicants will be discharged without waiting for conviction in the courts. It is to be commended for the move. If booze and bootlegging are evils in large cities, they prove doubly so in mining camps, where any pernicious influence is quickly and directly reflected in the operating results obtained. It is good business to suppress them.

Another aspect of the case presents itself: the company takes a decisive stand in support of the law. Whether the Eighteenth Amendment was wise is subject to debate. So long as it stands on the statute books it should be upheld. The present state of lawlessness in many sections of the country is disgraceful and alarming. The official corruption that goes with it, hand in hand, constitutes a real danger to American institutions that should not be ignored. It is time that those who disapprove openly declare themselves.

Life may have been fast and furious—and picturesque—in the old-time camp. But methods and men were also wasteful and efficiency was low. Times have changed. Today workmen are called upon to produce results unthought of then. To make the grade today a clear head and a sure hand and foot are necessary. The wanton disregard of the law militates against this.

In the KATANGA REGION, BELGIAN CONGO



Above—In the pit of the Star of the Congo mine, the first big enterprise of Union Miniere du Haut Katanga. Elisabethville is 9 miles away

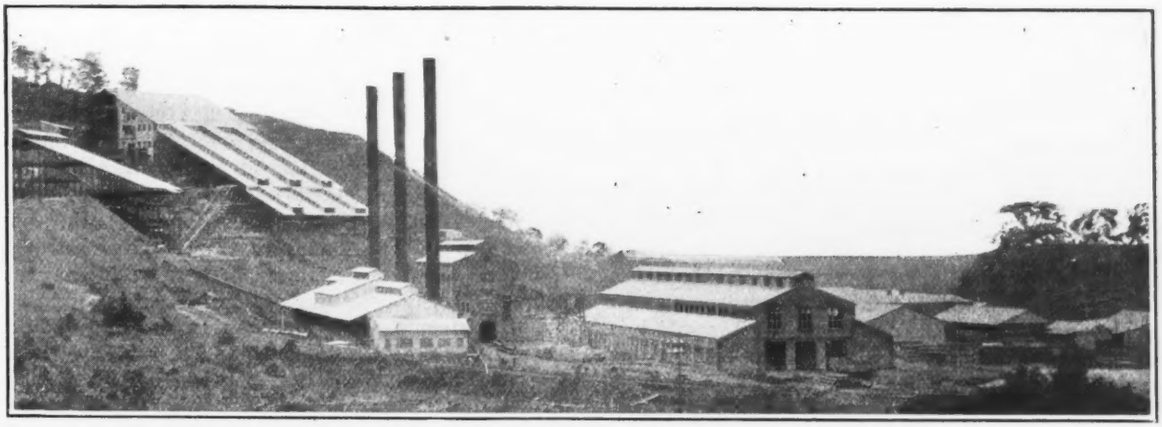
Oval—Limestone quarry near Panda, which supplies flux to the company's Lubumbashi smelter, 100 miles away.

Right—The Likasi mine, near the Panda concentrator, 80 miles from Elisabethville.

Below—Union Miniere's Ruashi mine. Stripping practically completed. The Kambove mine is shown on the cover.

Oval—Union Miniere's power house and shops at Panda. The concentrator is behind the hill at the left. Entrance to Likasi mine in foreground

Photos by courtesy of A. W. Newberry



Power station and concentrator at Union Minière du Haut-Katanga, at Panda, Belgian Congo

Katanga and Its Mineral Development

Solving Mining, Metallurgical and Transportation Problems in Central Africa

By Owen Letcher

Editor, the *South African Mining and Engineering Journal*

PRODUCTION OF COPPER by the mines of the Union Minière du Haut-Katanga, in the Belgian Congo, for the year 1924 was approximately 85,000 tons. In August, 1924, the Union Minière secured a record output of 9,111 tons, which made it (for that period) the largest copper producer in the world.

The copper fields of Katanga should possess a special measure of interest for readers on the American continent, inasmuch as the United States is the biggest copper-producing country in the world, and also because several eminent American mining and metallurgical engineers have played an important part in the exploitation of this remote and spectacular enterprise. Furthermore, there are rumors as to some disposition on the part of American capital to become associated with the enterprise either directly or with the completion of the Lobito Bay railway, which strikes straight toward the mineralized belt from the Atlantic seaboard and which will, when completed, afford a much more economical and expeditious outlet for the Congo copper mines than they now possess.

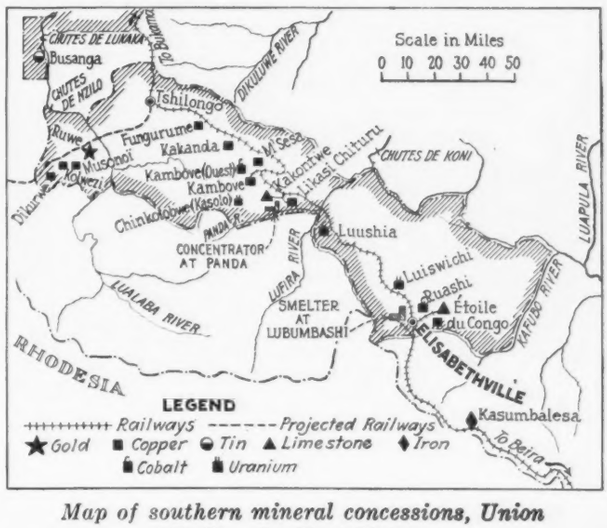
The Katanga "Copper Rand" may be said to extend over an area about 200 miles long from northwest to southeast and, say, 70 miles wide at its broadest point. The Lufira River cuts through this belt at approximately its narrowest width, where it thins down to about 20 miles. The most southerly property which is at present being worked is near Elisabethville, and is known as the Star of the Congo (l'Etoile du Congo), close to which is a highly important new property, known as the Ruashi mine, which has been opened up during the past three years and is now contributing a large tonnage of high-grade ore to the smelters.

The copper belt extends northward to Chilongo, eastward in the direction of Lake Mweru, and westward to Musonoï, and probably beyond Musonoï toward the Angolan border.

Associated with the cupriferous areas are less important, although noteworthy, deposits of tin and gold, uraninite, and other radioactive minerals, cobalt, and coal. These deposits constitute one of the most extensive and valuable mineral belts as yet discovered anywhere in the world, and they are all under the control of one great Belgian company, the Union Minière du Haut-Katanga, with which are associated the British enterprises presided over by Sir Reginald Wingate and Robert Williams, and known as the Tanganyika Concessions and the Zambesi Exploring Co.

The Union Minière in fact controls under one organization a mineral field even more extensive and almost as concentrated in its mineral values as the Witwatersrand, and next to the industry of the Main Reef series it easily ranks as the most spectacular and impressive mining enterprise of the African continent.

More than a century ago Portuguese travelers referred to the presence of copper in seemingly large quantities in this part of Africa. The immortal Livingstone also remarked on the cupriferous occurrences of this region, and it is probable that for many years there was in the Katanga an important copper-producing industry, operated under the supervision of



Map of southern mineral concessions, Union Minière du Haut-Katanga

the Arabs in conjunction with the slave trade and worked by conscripted native labor. But the history of what is today known as Katanga, like the story of most of Central Africa, is shrouded in darkness, occasionally illuminated by the reports of the adventurers and explorers of the Victorian era. We have to pass on to the early 90's before we find that there was any true assessment of the metal-producing possibilities of the region. At that time the Katanga was visited by two Belgian geologists, Cornet and Francqui, who directed the attention of the Belgian Government to the extensive deposits existing in the extreme southern part of the great Central African dominion for the administration and development of which King Leopold had assumed responsibility, when all other nations turned deaf ears to Stanley's entreaties for the establishment of good rule and order in the heart of the Dark Continent.

At this stage in the early history of South Central Africa, Cecil John Rhodes, the most far-seeing of all modern Englishmen, and his astute lieutenant of the Far North, Robert Williams, appear in the romantic picture. In 1895, Rhodes asked Williams to assist him to find mineral wealth in Northern Rhodesia. But at that time Mr. Williams was exclusively bound to the Zambesi Exploration Co., so Rhodes granted certain rights in which that company should have a large interest. To work these concessions a company—the Tanganyika Concessions, Ltd.—was formed. Williams organized a prospecting expedition and appointed the late George Grey as leader, with instructions to search for minerals as close up to the Congo State frontier as possible. Grey and his party discovered the Kansanshi copper mine, in Northern Rhodesia. Meantime, Williams approached King Leopold and succeeded in making an agreement with him—which gave the Tanganyika company the sole prospecting rights for minerals over 60,000 square miles of the Katanga district of the Congo State.

The distance between the great copper Rand and the ports on the south and east coasts of Africa has gradually been bridged. In 1906 the first train drew into Broken Hill, more than 2,000 miles distant from Table Bay, and there for a considerable time the iron horse came to rest. However, the Cape to Cairo railway was arranged for at last, and for some time it has been opened right through to Bukama, 2,600 miles north of Capetown, while the route to the mouth of the Congo has been connected by steamer and rail as the result of Belgian enterprise and energy.

The principal town in this region is Elisabethville, where are the headquarters of the administration under a vice-governor-general for the province. A mile or two from Elisabethville is the smelting plant of the Union Minière, at Lubumbashi, and here the company has its head offices in Africa. The whole of the Katanga is in an industrial and commercial sense dominated by the Union Minière, and Elisabethville's position in regard to this company is similar in several respects to that of Kimberley in relation to De Beers.

Elisabethville is a well-laid-out town, and contains a larger white population than any other settlement in the Congo.

From the southeasternmost corner of the Belgian Congo (about latitude 14 deg. S., longitude 30 deg. E.) the Congo Zambesi watershed makes a sharp bend, trending in one direction nearly W.N.W. to longitude 24 deg. E., where Portuguese Angola abuts against western Northern Rhodesia, and in the direction trending northeastward to longitude 33 deg. E., where it crosses into the British Mandate of Tanganyika Territory, formerly known as German East Africa. The country to the north of this divide is drained by the Chambezi, Luapula, Lufira, Lualaba, and Lubudi river basins, forming the main affluents to the Congo River, emptying into the Atlantic Ocean; and to the south the country is drained by the Luangwa, Lunsenfwa, Kafue, and Kabompo basins, forming northern affluents to the Zambesi River, emptying into the Indian Ocean.

The western part of this main divide is an undulating plateau, having an altitude of 4,000 to 5,000 ft. above sea level, and it forms the political boundary between the Belgian Congo and western Northern Rhodesia. It is along this watershed and to the north of it that the mineral belt occurs, and before dealing with the various mines of the Union Minière it may be well to state in brief form the outlines of the geology of this region as interpreted by Studt, who has at different times made a most exhaustive examination of the mineralogical and lithological character of Katanga.

In the Katanga country, rocks which may be correlated to the four South African systems—namely (1) the Swazi System; (2), the Transvaal System; (3), the Waterberg System; and (4), the Lower Karroo System—are found. In a table accompanying a most valuable paper read by Studt before the Geological Society of South Africa in June, 1913, he showed the general classification which he adopted for the Katanga rocks, and their probable South and Central African equivalents. In the northwest district, the Busanga and Nzilo beds are so interplicated that it is difficult to make out a succession of the rocks, and the task is further complicated by the metamorphic effects of the frequent granite intrusions, so that Studt has grouped them together as the Nzilo series (equivalent to the Kafubu beds of the southeast), and the Musofi magnetic banded sandstones (which he formerly correlated with the Hospital Hill beds) have been found to belong to a higher horizon, and no true equivalents to the Banket conglomerate have been found among the Kafubu-Nzilo quartzites. These rocks show no affinity to the Witwatersrand system, and have consequently been grouped with the Swazi system of rocks.

The Kundelungu beds of the Katanga show very strongly marked affinities to the Pretoria series of the Transvaal, as well as to the Table Mountain beds of Cape Colony, and investigation has shown that the Kundelungu beds form an undoubtedly conformable series with the underlying Lufira-Kambove-Wemashi sequence of beds, so that they have been grouped with the Transvaal system; they show no affinities to the Waterberg system of the south.

The Lubilash series of beds overlie the last system uncomformably, and a considerable interval of time elapsed between the Kundelungu series and the deposition of the Lubilash beds, as the beds representing the Transvaal system in Katanga were inclined and subjected to much denudation before the basal beds of the Lubilash series were laid down.

In 1906 the Belgian company, the Union Minière, took over, under arrangement with the Comité Special, the Katanga mineral concession, with all the discoveries which the Tanganyika Concessions company had made, the remuneration to Robert Williams' companies being a

40 per cent interest. Allan Gibb had latterly managed the mineral zone for the T. C. L., and soon after the formation of the Union Minière company, the administration naturally enough became more and more Belgian in character. But the Belgians did not profess to know a vast amount about copper mining and metallurgy, and therefore they employed, as the Rand had employed in its early days, technical men from America. They have continued to secure the best management and advice possible, and with men like P. K. Horner, A. S. Wheeler, and T. S. Carnahan to guide them, the Union Minière people certainly know a great deal more about copper mining and what it costs to develop and equip what is perhaps the most important cupriferous deposit in the world, and situated in remotest Africa, than they did when they went into the business.

Nationalities are strangely mixed in this mining field. The Belgians are under indenture, with provision for repatriation, and their wives and families come out on the second engagement. It is a condition of the mineral concessions that the Union Minière must employ 50 per cent of Belgians and use 50 per cent Belgian goods, and the population of this mining field today is composed principally of Belgians, with a big smattering of Britishers and a considerable number of Americans on the technical side of the job.

To the north of the copper belt is another mineralized zone running practically north and south and covering approximately the same area as the copper field. This belt comprises various tin mines, of which the Bussanga is the most important yet discovered, and which is yielding about sixty tons of cassiterite concentrates per month; the Ruwe gold mine, which includes both reef and alluvial formation, and which is now being reprospected; and the Sankishia coal field. The railway line continuing northwestward from Sakania and through Elisabethville passes through the belt to Bukama on the Lualaba (Congo River).

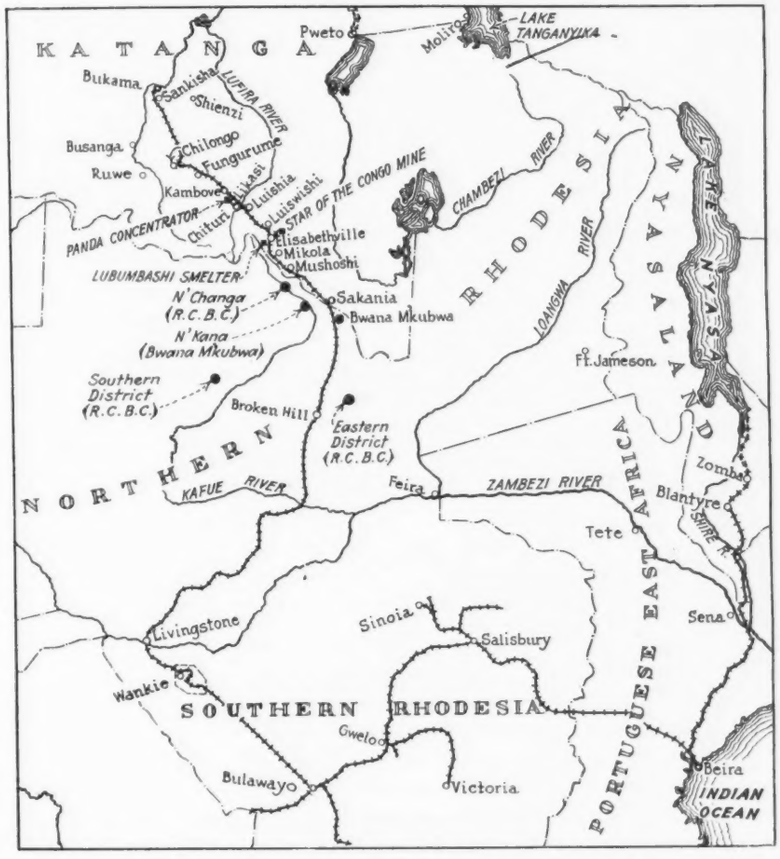
Broadly speaking, then, there are two main mineralized belts: (1) The copper belt, which, commencing in the vicinity of Elisabethville extends with a line of strike for a distance of 200 miles, and averaging perhaps 50 miles in width, and within which there are at least 200 outcrops that may in a sense be regarded as so many separate mines, but of which only about fifteen have so far been prospected and exploited; and (2) the mineralized zone containing gold, tin, and coal which lies to the north of the copper-bearing area.

The cupriferous ores occur in association with cellular quartzite and shale and in dolomitic limestone. This is the prevailing country rock of the district, and it may be remarked that where the dolomite is hard it seldom contains copper in any appreciable quantity. The question of the permanency or otherwise of these orebodies in depth has at one time and another been the subject of considerable speculation. Persistency in depth is a phrase in mining parlance which has a reassuring ring about it. But in Katanga the superficial and above-ground dimensions of the orebodies are so immense that the factor of perseverance in depth is at the moment and for many years to come of less importance perhaps than in any other metalliferous field.

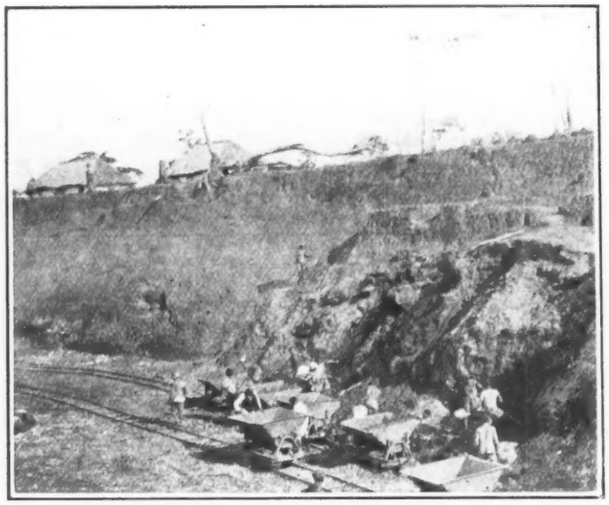
Most of the Congo copper occurrences are cut off by faulting at a fairly shallow depth and before the sulphide zone is reached. So far, the greatest depth at which copper-bearing rock has been proved in the Katanga is in the Luishia mine, where the orebody is not faulted and the country is flat. In this property sulphide ore has been located by boring at a depth of about 700 ft. In Katanga, the copper-bearing areas exposed in the hills or those which are available at shallow depth, as at Ruashi, are so extensive that the question of permanency in depth is hardly one of practical present-day commercial politics. The main line of strike of these cupriferous bodies is 30 deg. west of north.

The mineralization is often exceedingly complex, and the areas exploited include malachite, chrysocolla, melaconite, chalcocite, cuprite, native copper, bornite and erubescite, a double phosphate of copper and cobalt, and probably numerous other rare and possibly unidentified chemical mixtures of copper and other elements.

The copper deposits are confined entirely to the rocks of the Transvaal system, and are practically all found in the Kambove series of dolomitic rocks. Broad bands of crush breccia and fault conglomerates are common in the copper areas. In depth, the deposits follow the



Map of the Katanga region, Belgian Congo, in which the Union Minière's holdings are situated. Scale 200 miles to the inch



Opening up the Union Minière's Ruashi mine

cleavage of the rocks, which may cut across the original bedding at a considerable angle.

The ore zone in depth is parallel to the cleavage and not to the bedding planes. The ore zone also contains solid dolomites, having disseminated pyrites in depth, giving place to the superficial oxidized ore deposits near the surface.

The Bwana M'Kubwa (a mine lying on the British side of the watershed) and Star of the Congo deposits are very similar in type to the majority of the copper deposits along the copper belt. These deposits are generally lenticular in plan, the cupriferous rocks gradually merging into the barren ones at the surface. In the southeastern end of the belt they frequently occur in close proximity to the intrusive watershed granite, which is probably of Lower Devonian age.

Gold—The copper ores are always accompanied by traces of gold and silver, but several of them are connected with coarse gold found in the soil and in the neighboring stream beds, as at Kambove, Likasi, Musonoï and Ruwe. In the last two localities gold has been found in the rocks parallel to the cupriferous zones, and associated with palladium, platinum, and copper-lead vanadates. The gold in the rock, however, is very fine, whereas that found in the surface soil is coarse and nuggety, and shows no signs of attrition. At Ruwe there are also found small spherical shots of gold, which show a concentric structure, so that it is probable that the surface gold was derived from the reef, by solution in mineral waters, from which it was probably precipitated by organic matter.

The quartz veins in the lower Kambove beds frequently contain traces of gold, but always too poor to be of any value, and the quartz veins occurring in the Nzilo beds are also often auriferous.

Iron—Deposits of iron generally occur as interbedded hematite, often associated with manganese ores. These hematite beds are very persistent, and may be traced for miles along the strike of the rocks. In the south of Katanga they become magnetic and schistose (the former Musofi beds), and in the northern districts, as at Kambove, Ruwe, and Kolwezi, they are replaced by limonite deposits. These beds all occur in the dolomite series, and generally in close connection with the copper deposits.

At the Lufunfu iron deposit, near the Kabompo source, the hematite occurs as large, irregular bodies in the dolomite.

Radioactive Minerals—In the Chinkolobwe mine the Union Minière possesses the most important producer of radioactive minerals in the world.

Manganese—Manganese is frequently found in seams parallel to the bedded hematites, but at Kasekelua, in the Lufupa River basin to the west of the Kapenda plateau, an important cupriferous pyrolusite is found in the Wemashi conglomerate.

Tin—Tin deposits are found in the Nzilo rocks of the Urua tin belt, and also in similar rocks in southeast Katanga and eastern Northern Rhodesia. They are generally found near the granite intrusions, in veins in the quartz mica-schists and tourmalines; the veins vary from pure quartz veins to those which are practically pegmatites, with large pinkish feldspar and pink lithia mica, there being all grades between these two types of veins.

In the southeast they are found adjacent to a greisen containing abundant topaz. Alluvial tin deposits are connected with these veins and evidently derived from them.

In several of the properties opened up to date, ores of cobalt are mixed with those of copper.

After long investigations an economic process for the treatment of the cobalt ores has been found, and on May 1, 1924, three electric furnaces were put into operation at Panda for the treatment of cobaltiferous ores.

Principal Copper Mines

The Union Minière is at present working and producing ore from the following copper-bearing properties: the Star of the Congo; the Luishia; the Likasi; the Kambove; and the Ruashi. In addition other mines have been prospected, mining plans have been drawn up, and these mines are ready to produce at short notice if and when required. The properties falling within this latter category are: the Dikulwe; the Kolwezi; the Fungurume; and the Kakanda. The mine with the biggest tonnage as yet established or which can fairly be presumed to exist is Fungurume. Next in order of tonnage comes Kakanda. Neither of these mines has so far been worked for copper. Third on the list is the Kambove mine.

The following mines have been regularly worked during 1923-1924: Copper, Star, Ruashi, Kambove, Likasi; limestone, Kakontwe; iron ore, Kasumbalesa; tin, Busanga; uranium, Chinkolobwe; cobalt, Ruashi and Luishia.

Mining Operations

The following are the quantities of ore extracted in 1923:

Copper Ores

Figures are in thousands of tons

	Forwarded to Smelter	Forwarded to Concentrator	Placed on or Taken from Dumps
Star Mine	38,759	87,127	379,100 pl.
Kambove	79,050	538,708	88,885 pl.
Likasi	93,090	134,639	6,927 T.
Luishia	21,919	4,065	.....
Ruashi	2,508	803	.....
Total ore	235,326	759,842	474,912

Fluxes extracted and forwarded to smelter were as follows: Kakontwe limestone, 154,896,000 tons; Kasumbalesa iron ore, 105,756,000 tons; total 260,652,000 tons.

The ore reserves at the end of December, 1923, are given in the following table:

Southeastern Region:	Tons	Per Cent Copper	Total Copper Contained, tons
Smelting ore	2,700,000	19.56	514,469
Concentrating ore	9,200,000	7.93	723,761
Leaching ore	25,000,000	5.91	1,482,103
Low grade ore	3,300,000	2.84	94,195
Sulphide ores	7,700,000	2.97	227,964
Complex ores	5,800,000	5.81	335,684
	53,700,000		3,207,313
Western Mines			
Smelting ore	1,600,000	16.6	265,000
Leaching ore	13,000,000	7.16	930,000
	14,600,000		1,195,000

Total ore reserves Dec. 31, 1923, 68,300,000 tons, containing 4,575,000 tons of copper.

To obtain a bird's-eye view of the chief mining activities of the Union Minière at present it will be necessary first to deal with the chief copper producers. Primarily, there is the Star of the Congo mine, 9 miles from Elisabethville. This famous mine has been producing for a number of years and was the first big mining enterprise undertaken. For more than one mile it has been opened up from northwest to southeast. Here the true dip is vertical and the width of the orebody is over 59 meters. Where the ore is most dislocated the best values are found.

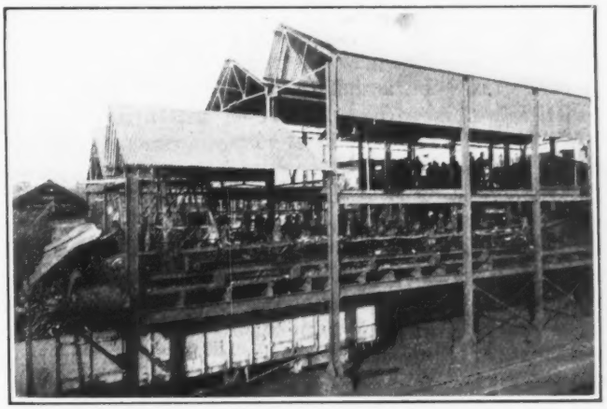
The Ruashi mine is situated two miles northwest of the Star of the Congo. This is a new discovery, but indications were known some time ago, and the company began prospecting in October, 1921. At Ruashi there is 30 ft. of overburden which has been stripped, and the orebody is as much as 60 ft. wide. The property opens up new possibilities of mining in the Katanga. The orebody is flat like a coal seam. Prospecting was carried on by drills 50 meters apart. Where values were high the drills were 25 meters apart. The Ruashi discovery has quite changed the immediate outlook of the company.

The Likasi mine is situated about 80 miles northwest of Elisabethville and in close vicinity to the Panda plant. The method of working is open-cast breast stoping in benches. There is one steam shovel at work. The dip of the orebody is 40 deg. to the west. This mine has produced about 500,000 tons of 12 per cent ore, of which 150,000 tons assayed about 20 per cent. The mine employs 640 natives and 18 whites. Likasi is not one of the big mines, but may easily last for seven or eight years more. The ore is cut off by faulting in depth. The rich high-grade ores go to the smelter and the poorer to the concentrator. Near Likasi is the Chituru mine, where leaching is employed as the method of recovery, the ore carrying about 8 per cent of metal.

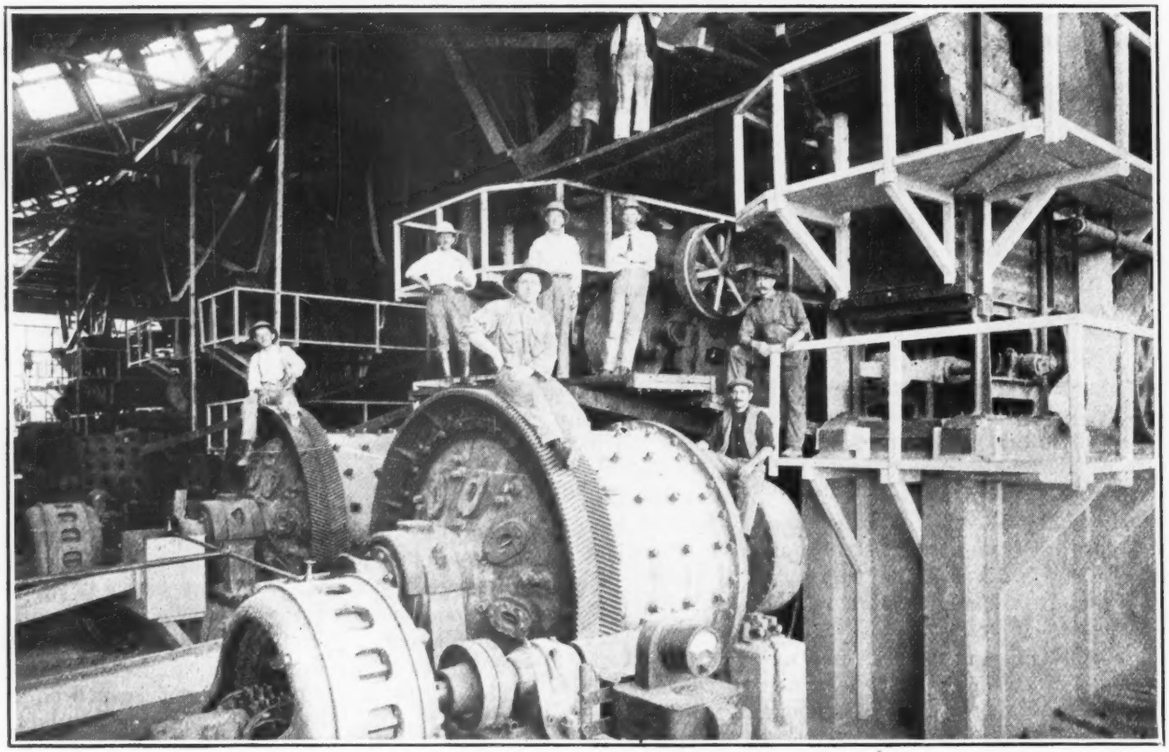
The Kambove mine is 18 miles north-northwest from the Panda and just 100 miles from Elisabethville. The orebody runs roughly east and west and dips at a flat angle to the north. It is 700 meters long and averages about 100 meters wide, and at one point it is as much as 200 meters wide. The ground in depth is cut off by faulting, and no sulphide ore has so far been discovered here. Other mines in the vicinity are Kambove No. 1, Kambove West, Messessa, and Kamoya. Sulphide ore has been discovered in depth in the Kambove West mine. Kambove has been working since 1914, and to date has produced 3,000,000 tons of ore. At the time of writing the company is producing ore assaying 16½ per cent, which is sent to the smelting plant, other ore assaying 8.9 per cent, which goes to the concentrator, and 6.7 per cent ore, which is sent to the leaching plant. The Kambove ore reserves are constantly exceeding previous estimates. The last estimate is in excess of the estimate made some time ago, despite the big tonnage taken out.

At the Kambove mine there are five levels or benches, known respectively as the A, B, C, D, and E levels. The top level is known as A and the bottom—the lowest at present being developed—as E. The mine has been attacked by means of benches, which rise upward on either side of a huge cut into the middle of the orebody and which have intersected it throughout the length of its longer axis from east to west. Four Bucyrus steam shovels are employed here.

The treatment of Katanga's ores has constituted a big and difficult metallurgical problem. Some of the earlier investigators, and particularly Mr. Frecheville (who visited Katanga in 1907), were by no means impressed with the likelihood of the discovery of an economical and effective process suitable to the carbonate ores of this great mineral belt. Mr. Frecheville's modified condemnation of Katanga copper was principally based on this debatable factor, and he laid stress on the remoteness of the property and the difficulty of securing coke. To import coke from Europe or America, even at pre-war rate of freight charges, would have taken the gilt off the gingerbread, even in the operation of such high-grade deposits as those controlled by the Union Minière. But the Wankie colliery, in Matabeleland, rose to the occasion. This Rhodesian coal company installed a large number of ovens, and in the last twelve years has supplied many thousands of tons of coke to Katanga. During the war period, this was supplemented by coke from some of the pits of far-distant Natal, but the Wankie colliery, which is 737 miles distant from the Lubumbashi smelter, has been the main source of supply of this essential commodity, and although few if any other copper smelters in the world have to draw their coke from such a great distance, the Katanga people, despite enormously high freight rates on the Northern Rhodesian Railways, have found the arrangement fairly satisfactory—so much so, that in 1922 the Union Minière renewed its contract with Wankie for a further period of eight years. Obviously, however, it would be to the advantage of Katanga if coal could be found nearer home, or preferably a coking coal and in the Congo colony. As though to complete the good fortune of the Union



Screening plant of Wankie colliery, Southern Rhodesia, which supplies most of Union Minière's coke and coal requirements



At Union Minière's Panda concentrator

Minière, which, within the far-flung frontiers of its concession seems to embrace every known kind of mineral, coal was some little time ago discovered near Sankishia, on the line of the railway from Elisabethville to Bukama and distant about 170 miles to the north of the Lubumbashi smelter.

In conjunction with the Bas Congo—Katanga Railway Co.—extensive prospecting has been done in this field, at least 20,000,000 tons of coal has been located, and a coal mine, known as the Luena colliery, has been opened there.

Sankishia coal cannot, by any stretch of the imagination, be described as high-grade fuel—that is to say, in so far as the deposit has been opened up. The coal from this field which I observed at the Lubumbashi smelter in 1923 and 1924 at any rate had a very "shaley" appearance and gave an immoderately high ash residue when burnt. It is, of course, by no means improbable that as more development work is carried out a better grade of coal will be encountered, and it also seems likely that the Union Minière management will be able to turn it to good account as pulverized fuel, a matter which is referred to elsewhere in this article.

While the Union Minière was experimenting extensively with smelting problems, and had indeed attained to production on a considerable scale at its Lubumbashi smelter plant, a discovery had been made in the United States which was destined to revolutionize methods of recovering copper from its ores. This was the application of the leaching process of recovery of copper ores in an acid solution by means of electrolysis. Of all methods so far discovered and applied this leaching process is most eminently suited to Katanga's low-grade ores, and although there are in the Union Minière's properties so many millions of tons of extremely rich ore that the management is not at present compelled to provide for the treatment of material having a metallic content of less than 15 or 17 per cent, it is indisputable that (unless something better is discovered in the meantime) the installing of a leaching plant of large capacity will be the most profitable policy which the company can pursue. But, on account of its cost, erection of such a plant may be delayed for a number of years, the more particularly so because of the recent discoveries of large quantities of high-grade ore in the Ruashi mine. However, every time one ton of rich ore is extracted, from two to ten tons of "low-grade" ore has to be mined with it. The amount varies with different deposits according to the mineralogy, structure, and constitution of the ores and the admixture of rich with poor ore. But in effect the situation is on all fours with that on the Rand and with mineral fields the world over; it is, in fact, the time-worn problem of getting the most out of a mineral venture and of securing the maximum of extraction consistent with the cost of securing the ultimate fraction of valuable content according to varying expenses of working and the selling price of the product. In this respect it may be pointed out that the so-called "low-grade" ore of Katanga are not poor in metallic content.

In other countries the so-called low-grade ores of the great Congo copper district which yield 6 to 7 per cent would be considered rich. The Rio Tinto and Chile copper deposits contain less than half this percentage of metal, and as to other African deposits, it may be pointed out that the Namaqua mines have a yield of 5 per cent or under; and the comparatively small and high-grade Messina mine yields only 3.23 per cent.

The term "low grade," used to designate the poorer of the Katanga ores, is thus a misnomer, but the expression when used to denote the vast tonnages which exist in Katanga and which are poorer in metallic content than the ores sent to the Lubumbashi smelter is legitimate enough in its application.

The company now claims a 77 per cent extraction, but it is somewhat difficult to confirm this and the figure is probably high. It recently installed a large reverberatory furnace for smelting rich oxidized ore at Lubumbashi. The production from this furnace for 1923 was 855 tons and for the first ten months of 1924 it was 3,419 tons. The Union Minière will probably postpone for some years the construction of a large leaching plant, on account of the enormous capital expenditure which is required for such an installation—especially when the rate of exchange of the Belgian franc is low; but the pilot leaching plant at Panda is in operation and in 1923 produced 1,024 tons, and for the first ten months of 1924 its production was 1,127 tons.

The old smelter plant at Lubumbashi consisted of three blast furnaces, which were blown in in 1911, 1912, and 1913. The new smelter plant, consisting of four blast furnaces, was started up in 1915. A further new plant consisting of a new furnace was started during 1922, and this has now been augmented by the new large reverberatory furnace.

The consumption of coke from Wankie is now about 9,000 tons per month, and this colliery is also supplying 4,000 tons of coal per month. The technical management has been experimenting extensively with a new method of utilizing pulverized coal from the Sankishia colliery, and a large coal-pulverizing plant is now being installed at Lubumbashi and is practically completed.

The mines are at present producing a high-grade blister copper of about 97½ per cent purity, but it is intended to refine the copper at the plant.

The iron ore used as flux in the Lubumbashi smelter is obtained from between Sakania and Elisabethville, and the limestone is principally drawn from the Kakontwe workings.

The recent discovery of fresh quantities of rich ore suitable for direct smelting, the large number of improvements made in 1922 in metallurgical operations, and the satisfactory results of the tests made with the reverberatory furnace for the treatment of rich fine ores, make it advisable that the company should not wait for the electrolytic leaching plant to be completed before extending operations and producing a larger output of copper. The company's expectations of a marked increase in production, and also a further reduction in costs as a result of working these new units, appear to have been fully realized during recent months.

Panda—A Modern Wonder

The concentrating plant at Panda began operations about the middle of 1921 and has a capacity of 4,000 tons per day. Panda is certainly one of the most wonderful places in Africa. After traveling miles and miles through the seemingly illimitable forest lands of Katanga, it is a revelation to round the brow of Likasi hill, and there before you to observe the huge concentration plant, the power house, with its tall chimney stacks, the extensive railway yard, and the well-built office, residential quarters, club house, hospital, and compounds—all in the heart of Africa. It is, in fact, a staggering spectacle.

Considered in the light of the probability of construction at some time of a big leaching plant, the erection of this huge concentration unit was probably unnecessary; but as the installation of a big leaching unit has been postponed, the Panda concentrator serves a useful purpose, and the concentrates from this now represent a substantial proportion of the charge to the Lubumbashi smelter. The Panda concentrating plant consists of three units each of nominal 1,200 tons' capacity in twenty-four hours. The latest available particulars with regard to the Panda crushing and concentrating plant are as follows: Ore treated in 1923, 755,237 tons; concentrates obtained, 160,737 tons; tailings, 552,028 tons; ore treated in 1924, (ten months), 876,818 tons; concentrates obtained, 170,087 tons; tailings, 664,042 tons.

The Panda plant represents an expenditure of approximately 150,000,000 francs (20 miles of railways and houses included).

The power station at Panda contains two steam turbine sets, each of 5,000 kw. capacity, of which only one-half is at present utilized. The power plant is fired by wood fuel. The boiler plant is also of double capacity. Immediately behind and to the right of the power plant is the crusher plant. This is a well-constructed galvanized-iron building with solid concrete foundations. The cement for this came from Bulawayo and Pretoria, but in this connection it is of considerable interest to learn that a cement-producing company has recently been established in Katanga.

The ore bins have a capacity of 5,000 tons. Below these are the primary breakers. There are four large Gates gyratory breakers. The secondary crushers consist of five smaller Gates breakers. These are supplemented by Allis-Chalmers Anaconda rolls.

Below the crushers is the concentrator plant. Ore containing about 10 per cent copper is fed direct into the concentrator along belts. The plant contains sizing trommels and jigs, and there are sixty Wilfley concentrating tables—that is, thirty on each of two floors. The concentrated ore is fed into 35-ton trucks and sent by rail to the Lubumbashi smelter.

Very fine malachite cannot be treated at the smelter, and is being dealt with by reverberatory and sintering furnaces. The tailings from the concentrator contain 5 to 6 per cent of copper, and these go to the tailings dam, where they have been stored for future treatment, and a flotation plant has been installed to treat them.

When the leaching process was discovered and so successfully developed in the United States between the years 1914 and 1918, the Union Minière, with commendable enterprise and promptitude, engaged the services of a distinguished American metallurgist to investigate the adaptability of this process to Katanga ores. An experimental leaching plant was installed and began production in November of 1921. This experimental leaching plant, which has a nominal capacity of 100 tons of copper per month, is situated next to the concentrating plant at the end of the hill. The process involves getting copper in solution as copper sulphate and precipitating electrolytically.

There is in Katanga, in addition to the rich ore now being treated, much so-called low-grade ore containing 6½ per cent copper, which cannot be treated by direct smelting. The company must look ahead to the day when it will have to deal with low-grade ores, and with commendable foresight the policy of providing for this eventuality is being followed. By the leaching process the Union Minière can recover 86 per cent from 6½ per cent ore and 95 per cent from 16 per cent ore.

The company will have to procure sulphur for making sulphuric acid. It is at present importing sulphur from America. The acid plant contains lead pipes and

lead chambers, some made in Broken Hill, Northern Rhodesia.

The leaching process has proved a success. The copper cathodes, after being smelted and cast into wire bars or ingots, will assay 99.9 per cent pure copper, and such a high-grade product will be delivered in Europe from 6½ per cent ore as cheaply as smelters can produce blister copper from 16 to 20 per cent ore at Lubumbashi by present methods.

The "pilot" leaching plant, already installed, gave a production during 1923 of 1,024 tons, and for the first ten months of 1924 the output from this plant was 1,127 tons.

A big leaching plant will probably eventually be constructed on the other side of Panda Hill, unless, of course, it becomes advisable to change the metallurgical processes applied to the treatment of the ores.

The leaching method has been considered on a basis of production of 25,000 tons, 50,000 tons and 100,000 tons of copper per annum, and the output from the reject of the concentrator and from low-grade and more siliceous and smelting ores might increase this to 150,000 tons.

The production of copper from the Union Minière to date, by year, is as follows:

	Tons		Tons
1911	997	1918	20,237
1912	2,506	1919	23,004
1913	7,409	1920	18,962
1914	10,724	1921	30,464
1915	14,043	1922	43,362
1916	22,160	1923	57,886
1917	27,462	1924	94,426

The question of transport has always been one of dominating importance to the Katanga copper fields. When the prospecting of this mineral region was undertaken by George Grey and his associates a quarter of a century ago, the railway from the south had advanced no further north than Bulawayo, in Southern Rhodesia, and there were no routes converging on Katanga from either the east or the west coast. Gradually, however, the Cape to Cairo route—one of the pet projects of the immortal Cecil John Rhodes—was forged northward, and from Broken Hill, instead of striking through Northeastern Rhodesia, as was originally intended, it was deflected to the Southern Congo. The line is now completed to Bukama, on the western headwaters of the navigable Congo, and passes right through the Union Minière territory. There can be no doubt, however, that the eventual natural outlet for Congo copper will be on the West Coast of Africa.

To provide a direct route from Katanga to the coast, the Benguella railway from Lobito Bay, in Angola, was begun twenty years ago, but its railhead is still a little more than 400 miles inland, and about 700 miles must be built to connect it with the existing railway from Capetown to Bukama.

The position was for a time complicated by the desire of the Rhodesian and South African authorities to retain the traffic to and from Katanga, which now passes over their railway systems. Since the war, however, the Belgians have shown a strong inclination to develop a national route to Katanga from the Congo mouth. This is to be achieved by the extension of the Katanga Railway from its present terminus at Bukama to Ilebo, at the junction of the Kasai and Luchwani, a distance of about 620 miles. Thence the Kasai is navigable by fairly large steamers to its confluence with the Congo, and the vessels can continue downstream to Kinshasa, on Stanley Pool, whence a railway runs to the estuary port of Matadi, to which ocean steamers ascend. By this route it will be possible to reach Katanga from the Congo mouth with only two changes.

Construction of this new railway from each end was started in 1923, and it is anticipated that the line will be completed late next year or in the early part of 1927. When this is completed the Belgians will have their own all-Congo route out to the Atlantic.

The transport problem is still difficult and complicated by exchange rates. The Union Minière has for years been trying to determine and to adopt the most economic route to the seaboard. Transport charges constitute more than half the costs of operation, and the consummation of the company's projects is mainly dependent upon a satisfactory solution of this dominating problem. It is probable that at least four routes will radiate from Katanga, of which two are now available—namely, the all-rail route to Beira, which necessitates a sixteen-hundred mile haul, and the rail and water route via Bukama and Albertville across Lake Tanganyika to Kigoma, and thence along the central railway line to Dar-es-Salaam. The Union Minière is under contract to take Wankie coke and to ship copper over the Rhodesian railways through Beira up to a certain amount until 1930, but the company for the last few months has been experimenting with sending a part of the surplus tonnage to Dar-es-Salaam. This is probably cheaper than exporting the company's product through Beira.

Latest available particulars as to copper transported are: Copper shipped through Beira in 1923, 54,330 tons; copper shipped through Dar-es-Salaam in 1923, 2,730 tons; shipped through Beira in 1924 (ten months), 63,866 tons; through Dar-es-Salaam (ten months), 6,880 tons; other shipments through Beira in 1923, 1,034 tons; in 1924 (ten months), 297 tons.

When I was in New York a few months ago I sought the opportunity to discuss with some leading business men there the probable and possible effects of the Congo output upon the copper markets of the world during the next few years, and on my return to Europe I paid a flying visit to Brussels and discussed with high officials of the government and of the Union Minière the position of and outlook for this great industry, which has risen up in the heart of the Dark Continent. I am not at liberty to enlarge upon the opinions and prophecies I heard expressed, but I will say that in the United States I found little disposition to regard Katanga as a serious rival to the big South American and North American producers, whereas in Belgium I sensed a feeling of confidence that in the very near future the Union Minière will easily outdistance the production of all its competitors.

Time must deal with these questions, but in bringing this article to a conclusion may I be permitted heartily to congratulate our Belgian friends on their magnificent achievement? By their courage, industry and ability they have established in the heart of Africa, in a region which only a few years ago was mere pristine bush, without railways or roads or European habitations, one of the greatest branches of the mineral industry in the world. They have added luster to the fame which Africa has rightly gained as a mineral producer, and they are writing history in capital letters of achievement in the core of the Dark Continent.

The Later Story of the New Cornelia Enterprise

An Outline of the Mining and Metallurgical Development in Recent Years, with Some Details of Present Leaching and Electrolytic Precipitation Practice

By T. A. Rickard

IN OUR ISSUE of Jan. 7, 1923, I told the tale of the early days of the New Cornelia enterprise, detailing the vagaries of various inexperienced operators and promoters during the incubation of this mining venture. That opera-bouffe stage of New Cornelia's history was ended when the direction of affairs was taken by John C. Greenway as manager and Louis D. Ricketts as consulting engineer for the Calumet & Arizona Mining Co. in 1913. Since then the story has been that of the establishment of large and successful industrial operations on the safe foundation of the latest mining and metallurgical technique.

The resources of the property were ascertained by systematic diamond-drilling, which was done by the E. J. Longyear Co. of Minneapolis. At the end of September, 1913, a total footage of 23,097 had been drilled by means of 84 boreholes, as well as 77 test pits aggregating 3,955 ft., the result being to indicate 11,954,400 tons of carbonate ore, averaging 1.54 per cent copper, and 28,303,600 tons of sulphide ore, averaging 1.50 per cent copper. The gold and silver contents of this ore amounted only to 15c. per ton.

The next step was to make experiments with a view to the treatment of the oxidized ore by means of a leaching process. This experimental work was done in a painstaking and thorough manner by Stuart Croasdale, followed later by Henry A. Tobelmann, James A. Potter, and others, over a period of nearly four years. The leaching plant, of 5,000 tons' capacity, started in March, 1917. Meanwhile the adjoining mine of the Ajo Consolidated Copper Co. had been drilled likewise by the Longyear company, with the result that 11,000,000 tons of 2½ per cent ore was proved to be available. In July, 1917, the New Cornelia company acquired the property of the Ajo Consolidated, which, by that time, showed 21,000,000 tons of 1.55 per cent ore. The diamond drilling was continued until a grand total of 71,000,000 tons of ore had been proved; of this, 12,000,000 tons was oxidized and 59,000,000 was sulphide, the grade of both being 1½ per cent. In November, 1918, the first dividend of $450,000 was paid. So far a total of $5,850,000 has been distributed to the shareholders.

While the oxidized ore was being exploited, the staff made experiments with the flotation process with a view to treating the sulphide ore. The construction of the mill of 5,000 tons' capacity for the treatment of sulphide ores was started in October, 1922, and the plant began work in January, 1924. In March of that year 107,445 tons of ore was treated in this mill.

At the end of April I visited Ajo and obtained a part of the information on which this article is based, but it is proper to acknowledge my indebtedness to the scholarly series of articles on the New Cornelia written by Arthur W. Allen in the *Journal-Press* of June 3, 10, and 17 and July 29, 1922. Mention should also be made of the series of papers on the subject in the *Transactions* of the Institute, notably those by Ira B. Joralemon, H. A. Tobelmann, James A. Potter, Stuart Croasdale, H. W. Morse, and L. D. Ricketts during 1914 to 1919.

The New Cornelia is a genuine "porphyry-copper" mine, for the ore-bearing formation is a monzonite porphyry, which has irrupted into and lifted an older rhyolite. Both these igenous rocks are penetrated by dikes of diorite or diabase porphyry, which, according to Joralemon, are allied to the flows of Tertiary lava that cover so much of the surrounding desert. The only sedimentary rock in the district is a conglomerate containing fragments of the rhyolite and monzonite. The chief structural feature of the local geology is the domed shape of the monzonite-porphyry extrusion, which represents the crest of a laccolith or batholith, the covering of which has been removed by erosion. The copper ore forms part of the southern portion of the monzonite, where its surface slopes south-eastward under the rhyolite. Both the monzonite and rhyolite are thoroughly shattered by a series of fractures, along which the mineralizing solutions have been at work. The copper minerals are chalcopyrite and bornite, which along some of the larger fractures form small veins of ore. Where these are parallel and close together they constitute bands 10 to 100 ft. wide of 3 to 5 per cent ore, such as incited the first mining operations in the locality. These bands of relatively high-grade ore, however, are too irregular and non-persistent to be mined separately with economic success, so that the profitable exploitation of the copper-bearing rock has been based upon the wholesale treatment of the mass of monzonite as a low-grade deposit. The area covered by the orebody is sixty acres. The depth of the rock rich enough in copper to be worth mining varies in such a manner as to indicate a mushroom shape, for at the edges it is less than 50 ft. thick and at the center it extends to a depth of 700 ft. The average depth is 400 ft. The boundaries of the ore are determined by assay, not by lines of structure or by differences of petrography. The best ore is in the ground that has been fractured most intensely.

It is anticipated that 80 per cent of this orebody can be dug with the steam shovel. So far 400,000 cu.yd. (or 800,000 tons) of stripping has been done to get at the ore underneath. The "cap" of unprofitable material that covers the workable ore consists of rock that has lost most of its copper by leaching, the metal thus removed being precipitated at the line of groundwater in the form of chalcocite, which, however, forms only a thin layer, and is not an important factor in the economic geology.[1] The separation between oxidized and sulphide ore is marked distinctly along an almost horizontal plane, which coincides with the present line of ground water; it is found at depths varying with the topography, from 20 ft. below the beds of the arroyos to 750 ft. below the tops of the hills.

The pit or open quarry in which the digging is done is now 4,800 ft. long by 3,800 ft. wide. Five steam shovels of the Mesabi type are used, and they have proved so satisfactory that after seven years' work it

[1] "Some Problems in Copper Leaching," *Trans.* A.I.M.E., Vol. 52, pp. 737-746.

has been found advisable to repeat the original equipment. The Osgood steam shovel, which is the one in use, weighs 105 tons and has a dipper that holds four cubic yards. The dipper has the self-sharpening teeth and the detachable hook invented by Fred Ekman, the superintendent of the mine. The standard loading-bank is 30 ft. high. The ore is removed by Oliver engines, of 65 tons, which pull trains of six air-dumping cars, each holding forty tons and made by Kilbourne & Jacobs. The track is of standard gage. The total equipment for moving 5,000 tons per day consists of five locomotives and fifty-two cars. On its way to the crushers the ore is sprayed, to prevent an excess of dust. Of the men employed in the mine, 45 per cent are Papago Indians and Mexicans, in about equal proportion. They make good workmen and are not affected adversely by hot weather.

The work done has proved that the average thickness of the carbonate ore is 120 ft. and the maximum 200. So far 9,000,000 tons of this oxidized ore has been removed.

Early Metallurgical Work on Oxidized Ore

Now we come to the metallurgical treatment of the oxidized ore. This is one of the most creditable chapters in Western American mining enterprise, for the task was undertaken with keen discernment and cool sagacity. The work was done cautiously; for a year the experiments were done in a one-ton plant; then for ten months a forty-ton plant was tried; after which a mill of 5,000 tons was built. The ore contains copper as chalcopyrite and bornite, with a little cuprite also, in a finely disseminated condition, associated with magnetite and pyrite. The silica content is 66 per cent, that of alumina about 12 per cent, and of lime one-half of 1 per cent. Laboratory tests showed that the ore could be crushed with the production of but little slime, and that the copper could be dissolved in dilute sulphuric acid when the crushed ore contained fragments no larger than 6-mm. cubes. Roasting with salt and leaching the raw ore with sulphuric acid were tried, and discarded.

Stuart Croasdale ascertained that the ore if crushed down to 8-mm. cubes would yield 80 per cent of its copper to a 5 per cent solution of sulphuric acid, and that the extraction could be increased to 85 per cent with finer crushing and more time. Utley Wedge demonstrated that sulphuric acid of 55 to 60 deg. Bé. could be made at a low cost from the sulphide ore that went to the reverberatory furnaces of the Calumet & Arizona smelter at Douglas. Thus at the beginning of the investigation the idea was presented of manufacturing acid, dissolving the copper in the oxidized ore, and then precipitating the copper on metallic iron, with the production of an impure cement copper that would have to be smelted and refined. Various experiments in the making of iron, in sponge form, for use as a precipitant, proved unsuccessful; so the next step was to try sulphurous acid gas, or sulphur dioxide, as a precipitant for the copper; but this also was set aside as unsuitable for the conditions prevailing at Ajo, where it would prove too complicated and too costly, as Dr. Ricketts has stated.[1] Thereupon the electrolytic deposition of copper from a sulphate solution was investigated. The first thing done was to ascertain the extent of the possibly deleterious effects of iron and aluminum sulphates, both of which would dissolve copper from the anodes. Experiments were conducted by F. L. Antisell, who used a graphite anode, and also by Frederick J. Pope and A. W. Hahn, at the Raritan Copper Works, in New Jersey. Meanwhile, Mr. Greenway ascertained that "if a certain copper solution containing salts of triad elements is treated in a simple way, the iron or aluminum triad salts may be removed." This cryptic statement, by Dr. Ricketts, preceded application for a patent, No. 1,224,458, issued to Messrs. Greenway and Morse on May 1, 1917. The important point was that instead of an acid electrolyte it was found advantageous to use a neutral solution, and thereby maintain a low content of ferric iron.

As put into practice in the big plant, which was started in 1917, the process consists of the following principal operations: The acid solution is circulated through the ore in a series of vats, the part that goes forward through the series being returned to a fresh charge of ore. By this time, when it is nearly neutral in reaction, the solution is passed through towers in which it is sprayed in contact with sulphur dioxide gas, thereby reducing the ferric iron to the ferrous state. For the purpose of removing impurities, which accumulate in the solution, a portion of it is withdrawn and replaced with fresh water. This discarded solution, slightly acid, is run over scrap iron, for the precipitation of cement copper, which is washed off, redissolved, and made into cathodes. It used to be sent to the smelter at Douglas. The main body of solution goes from the vats to the electrolytic cells, where the copper is precipitated on lead anodes. The iron in the electrolyte is kept down to 2 per cent, of which only one-half of 1 per cent is ferric.

How the Oxidized Ore Is Milled

The oxidized ore, broken at the mine to less than a maximum size of 40 in. cube, is discharged by the train of six cars, one after the other, into a 48-in. (No. 24) gyratory crusher. It is an impressive sight to watch the big fragments of ore tumbling into the maw of the breaker, with its suggestion of relentless power. The 48-in. crusher discharges directly into four smaller (No. 8) gyratory crushers, two on each side, which reduce the ore to 4-in. cubes. This is conveyed on two 36-in. belts to the storage bin, which holds 10,000 tons. From here the ore is drawn automatically onto five 20-in. belts, which convey it to five Symons 48-in. vertical disk crushers, each of which delivers its product, by an elevator, to a grizzly, the oversize from which passes to ten more Symons crushers of the same type and size. Preliminary experiments proved that the disk crusher yielded a product more granular than that from the rolls. The reduction in the Symons machines is supposed to be to *minus* 3 mesh, but 20 per cent of *plus* 3 mesh is obtained, owing to the platey fracture of the ore. These oversize fragments, however, are so thin that they present no obstacle to solution. The maximum penetration of the acid is ⅛ in. during the period of treatment. In the process of reduction to the size most suitable for leaching, the ore makes much dust, most of which is caught by an exhaust fan. To those familiar with such operations the dust may seem slight in amount, but to a detached observer it looks as if the dust in these dry crushing mills represented not only a loss of ore but a factor injurious to the health of the operatives. Much remains to be done in abating this nuisance.

The ore, as it leaves the fine-crusher building, is weighed and sampled before being conveyed to the leaching vats. The sampling is done by a slot bucket on a traveling chain, taking 1 per cent of 5,000 tons; this portion is crushed by rolls before it is further sampled in the same manner, 1 per cent of the fifty tons being taken, and from that again 1 per cent; so that, 1,000 lb. survives. This last is halved by a bucket sampler, the resulting 500 lb. being then split-shoveled by hand to a final sample weighing 8 pounds.

Filling the Leaching Vats

The crushed ore is carried as desired to the various vats by a 28-in. belt conveyor, which delivers the ore across the width of the vat by aid of the device known as a spreader bridge. The delivery begins at one side of the vat and continues until the full height is reached; then the machine is moved at intervals, electrically, so that the ore falls in a succession of ridges of equal height, which represents the depth of the charge. Thus the coarse particles fall to the bottom on a slope of 45 deg. The filling of a vat is completed in twelve to fourteen hours.

Each of the twelve vats is 88 ft. square and 18 ft. deep. Their walls, of reinforced concrete, are 9½ in. thick, strengthened by concrete buttresses on the outside. The vats stand on concrete piers. Their bottoms consist of 3x8-in. pine planks set edgewise upon the concrete foundation and covered with a sheet of antimonial lead weighing 6 lb. per square foot. This hard-lead floor slopes slightly to the center; on top of it are laid the 5x12-in. joists, on 16-in. centers, that carry the 2-in. planks on which the ore rests. These planks are pierced with ⅜-in. holes, spaced 2 in. apart, and countersunk from below, for drainage of the vat. The sides of it likewise are lined with lead, a little heavier than on the bottom—namely, 8 lb. per square foot. This also is protected from abrasion by 2-in. planks, fixed in place by vertical posts, clamped both at bottom and at top. At the start this lead lining was left uncovered, but it was found that the channeling of the solution abraded the lead, so that it had to be protected with plank dunnage.

Wormy Lead Sheets Cause Leakage

When the plant was started the lead on the bottom of the vats was found to leak in an extraordinary manner. Examination disclosed the fact that this leakage was caused by worms that actually had bored their way through the ⅜-in. sheet of lead. When the acid solution ran into their holes, they were killed, of course. It was ascertained that they were in a particular lot of lumber. I may add that Percy, in his "Metallurgy of Lead," records observations made in 1844 by Demarest in regard to the perforation of sheet lead by "a species of coleopterous wood-borer, *Bostricus capucinus*." It is recorded also that bullets used by the French in the Crimean war were pierced by a hymenopterous insect, contained in the wood of the boxes in which the bullets were imported.

Leaks in the lead are watched by the lead burner, who goes under the vat and marks the spot. When the vat is empty, he repairs it. If the acid is allowed to get into the soil, which is full of *caliche* (a natural cement of lime carbonate) the ground swells and rises, so as to heave any foundation that may be lying upon it. Therefore the site of the entire plant is now paved with asphalt. If the acid goes through a crack in the asphalt, it raises a big blister, which has to be chiseled out. The leakages, however, are slight—three or four gallons per minute at the most.

The vats are emptied by means of an excavator of the type used for unloading iron ore at the Lake ports. This machine travels on a track and spans the vat. The grab bucket, or scoop, holds twelve tons and excavates a vat in eight hours. The unloader now in use has been at work for seven years uninterruptedly, needing only minor repairs, chiefly to the cables that open and close the bucket. It is neither necessary nor advisable to empty the vat completely; about four inches of tailing is left on the bottom and is shoveled by hand in windrows, to facilitate percolation. This reject from the vats is put, by the excavator, into air-dump cars like those used for transporting the ore from the mine to the mill. Twenty-two trains, each of eight cars, are required to remove the contents of one vat, in ten and one-half hours, or at the rate of 500 tons per hour.

How the Leach Solutions Are Handled

One vat is used as a settler. Of the twelve used for leaching, eight contain ore in process of treatment. Each vat holds 5,000 tons of ore and 300,000 gal. of solution. If, now, we suppose No. 10 to be the oldest in the circuit and No. 6 to be receiving a fresh charge of ore, No. 7 is empty, No. 8 is being emptied, and No. 9 undergoing the operations of washing and drainage. The normal advance of the solution through the successive vats is at the rate of 1,000 gal. per minute. Overflow launders, along the opposite sides of each vat, deliver to centrifugal pumps, two for each vat. As soon as No. 6 is filled, the ore is submerged by an ascending solution, from the electrolytic cells, at the rate of 2,000 gal. per minute, the increase being made by drawing from the storage vats. Meanwhile the usual advance of 1,000 gal. per minute is delivering solution from No. 5 vat to the reduction towers and the excess solution is filling vat No. 6 until the ore is covered completely. Thus there is no interruption in the regular flow of solution to the towers. As soon as the ore in No. 6 is covered, the additional flow of solution is stopped. Then the solution in No. 6 is circulated within the vat for four hours, when it is clarified. This vat is now put into circuit and the neutral solution for the towers begins to proceed from this vat, instead of No. 5. The leaching of the ore in No. 6 continues for eight days; meanwhile the free acid in the solution going on the ore is increased from 0.3 per cent on the first day to 2.3 per cent on the eighth. A little acid is added to the electrolyte so as to make this strength. Each day the 2.3 per cent solution moves forward one vat. The 0.3 per cent solution goes through settlers and then to the reduction towers; it contains 0.5 per cent of $Fe_2(SO_4)_3$, 0.8 per cent of $FeSO_4$, and 2.8 per cent of copper as $CuSO_4$. Thus 2 per cent of acid is consumed, and the ferrous sulphate is increased to 0.5 per cent. Meanwhile as much as 2 per cent of $Al_2(SO_4)_3$ and other impurities have accumulated in the solution; they are eliminated by discarding the strongest wash water (130,000 gal. per day) and removing the copper from it by precipitation on scrap iron, which comes from Los Angeles. An attempt was made to produce sponge iron, as a precipitant for the copper, from Bisbee pyrite after roasting, but it was found cheaper to buy scrap iron.

The piping of the circulatory system is made of lead in diameters of 12, 15, and 18 in. The valves also are made of lead, with rubber diaphragms. The original contract for $1,250,000 worth of lead was placed with the Selby smelter, at San Francisco, and was the largest individual order that smelter had ever received. An immense quantity of fittings is needed for the control and distribution of the solutions. The pipe is now made on the ground out of sheet lead, which comes from the Selby plant in rolls weighing one ton. Other parts are cast from the same material. Ten per cent of antimony is added. The scrap is sent back to Selby. Two lead burners are employed. The ferric iron in the solution, now enriched with the copper that it has leached from the ore, is an obstacle to electrolytic precipitation on account of the consumption of electrical energy by the alternate oxidation and reduction of the iron. So the ferric iron has to be reduced to the ferrous state. This is the key to the success of the leaching process as a whole. It is effected by means of sulphur dioxide gas, which is made from a low-grade pyritic ore that is shipped from Bisbee to Ajo. This ore contains 40 per cent of sulphur; after the sulphur has been extracted by roasting, it is returned to the railroad cars in which it came and is sent to the Calumet & Arizona smelter at Douglas. No attempt is made to desulphurize completely, the sulphur content being reduced only to 7 per cent. The aim is to produce a gas containing 10 per cent of sulphur dioxide. Three seven-hearth Wedge furnaces are in use; these roast fifteen tons each, or forty-five tons per day when working on a full scale. About eighty-five tons of acid is produced daily, to which is added eighty tons of acid made in the smelter at Douglas.

The gas from the roasters passes to a Cottrell precipitator, where any dust is removed; then it goes to a chamber in which it is cooled and sprayed. This chamber is 14 ft. square by 94 ft. long; it is built of 8-lb. sheet lead supported on a wooden framework, over which are distributed the thirty-eight nozzles that deliver the solution in the form of a spray. This cools the gas from the roasters, the temperature being reduced from 600 deg. to 150 deg. F. Besides cooling the gas, the spraying of the solution in the gas has the effect of reducing the ferric iron, so that this solution, after having cooled the gas, is joined to that which comes from the towers. Of these there are three pairs; the two first built are each 40 ft. high and 20 ft. in diameter; they are built of sheet lead with a steel frame. Two others, built in 1918, are 28 ft. in diameter and 40 ft. high, but these are made of ordinary redwood, like a water tank, hooped with iron rods. These wooden towers are painted with asphalt, and covered with three-ply roofing paper, under the hoops, so as to prevent leakage. The towers stand upon a reinforced concrete base, and are provided with a lead fan. They are filled with a checker-work of boards, $\frac{3}{8}$ in. thick and 11 in. wide, placed on edge, the thickness of a board apart, and in layers, each of which is at right angles to the next one. This baffling causes an intimate contact between the solution and the gas. A fan, made of lead, draws the gas from the roasters through the Cottrell precipitator, the spray chamber, and the third set of towers, and forces it through the other two sets into the atmosphere, by which time it has been thoroughly impoverished and its temperature is that of the air outside. The solution, or neutral advance from the vats, travels countercurrent to the gas; that is to say, the most reduced solution meets the strongest gas. At the bottom of each pair of towers is a lead-lined concrete sump, 6 ft. deep and 50 ft. long, into which the solution flows, and from which it is pumped through the next pair of towers.

Arrangement of Precipitating Tanks

The copper-bearing solution, now in a condition suitable for precipitation, goes to a building 166 ft. by 280 ft. in which the electrolytic cells are arranged in series. These cells are made of Oregon pine lined with chemical lead weighing 7 lb. per square foot; they stand on concrete columns and are insulated by tile blocks that are covered with caps of sheet lead. Each cell is 29 ft. 7 in. long, 4 ft. 9 in. wide, and 4 ft. 3 in. deep. It holds eighty-four anodes, made of lead containing 3.5 per cent of antimony and weighing 215 lb., the dimensions being 40x50x$\frac{1}{4}$ inches. The starting sheets are made on lead blanks in two days; then they are stripped and squared, and loops are attached to them. I noticed none of the usual fume; this is checked by pouring oil on the electrolytic bath so that the bubbles of gas break underneath. A skimmer prevents the oil from escaping from the cell. Many useful improvements in the insulation of anodes and cathodes have been developed by the members of the staff. The starting sheet is allowed to increase, from its original weight of 16 lb., to 120 lb.; then it is pulled, washed in hot water, and shipped to the Raritan refinery at Perth Amboy, in New Jersey. There the cathodes, assaying 99.7 per cent, are not "refined," but melted and cast into wire bars, billets, and other shapes, as required. The copper contains one- to two-tenths per cent of chlorine, which is derived from the sodium chloride in the water. It becomes cuprous chloride in the electrolytic cell and is separated on the cathode mechanically. This cuprous chloride is lost as fume in the melting at the rate of half a pound of copper per pound of chlorine.

The scraps of copper at the mill are baled by hydraulic pressure and shipped with the cathodes. The refuse from the floor, such as dust and nodules, is dissolved in a solution of ferric sulphate, which operation serves to illustrate the negative function of ferric sulphate in a leaching process. The cost of leaching is 27.5c. per ton of ore, that of electrolytic precipitation is 2.17c. per ton, and of the crushing, 15.7c. The cost of mining is 36.3c., and of power $\frac{3}{4}$c. per kw.-hr. The fuel used for generating power is oil, at the rate of one barrel for 315 kw.-hr. In December, 18,230 bbl. of oil was delivered at Ajo.

An Outline of the New Mill

A few notes on the new mill will be timely. This consists of a crushing plant and a flotation concentrator with a capacity of 5,000 tons daily; work on it was begun in October, 1922, and it went into operation on Jan. 8, 1924. The receiving hopper holds 500 tons, but I noted that the pan conveyor underneath started into motion smoothly. It never pulls over 30 kw. The ore is crushed in a 54-in. McCully gyratory machine that is set to yield a 7-in. product. This is stored in a 5,000-ton bin, from which four No. 8 Gates (style K) crushers are fed. In front of each of these is a 2-in. grizzly. From the crushers the ore travels on 30-in. belts to four Burch rotating grizzlies set to 1$\frac{1}{2}$ in.

Thence it goes to 48-in. Symons disk crushers, the product of which is conveyed to Traylor rolls (78 by 24 in.) set at half an inch, the discharge from these passing direct to the mill bins. Under the rolls is placed a splitter, which takes the oversize that normally passes through the cheek plates of the rolls; by means of this splitter the product is returned to the rolls.

When delivered to the flotation department the ore has been reduced so that 32 per cent rests on a ½-in. screen and 68 per cent passes through. It is delivered by two 42-in. belts, which discharge upon one 24-in. belt (provided with a Merrick weightometer), from which it is discharged and divided between the two primary Marcy rod mills, of 6 by 12 ft. size. The discharge from each of these mills goes to a 6 by 28 Dorr classifier on which there is a circulating load, 60 per cent going to the secondary rod mills, which also are 6 by 12. These four rod mills of each unit (of which there are five) deliver a product 4 per cent of which would rest on a 65-mesh screen. All the overflow from the classifier goes to the first, or rougher, flotation cells, which are machines of the Callow-Inspiration type modified by the company's consulting engineer, Kenyon Burch, who designed the mill.

Tar is added to the ore when it is in the rod mills, at the rate of half a pound per ton. Pine oil is added, at the rate of one-tenth of a pound per ton, at the turn box before the rougher cells. Each 1,000-ton unit has four banks of twelve cells apiece. The rough concentrate goes to eight cleaning cells, and then to as many re-cleaning cells. The foundations and floor afford space for a series of Deister Plat-O tables, but none is in use as yet. A test run for a month showed that the saving on the tables did not justify the additional operation at present. From the flotation cells the concentrate goes to ten Dorr tanks, 8 ft. deep and 58 ft. in diameter, from which the dewatered slime goes to a collector tank, also 58 ft. diameter, from which it runs by gravity to an Oliver filter (14 by 14 ft.). Four of these are in place, but their capacity is such that one more than suffices. The concentrate, now containing 12 per cent water, is discharged upon a 24-in. belt that delivers it into a railroad car of special design and of sixty tons' capacity.

The quarry from which the stone for the concrete of the new mill was obtained is now a reservoir. The excavation represents 26,000 cu.yd., and it contains a million gallons of water. This comes from a shaft six and a half miles away, and when I put my hand into the clear stream as it issued from a pipe, I was surprised to find it warm. The temperature was 104 deg. F.

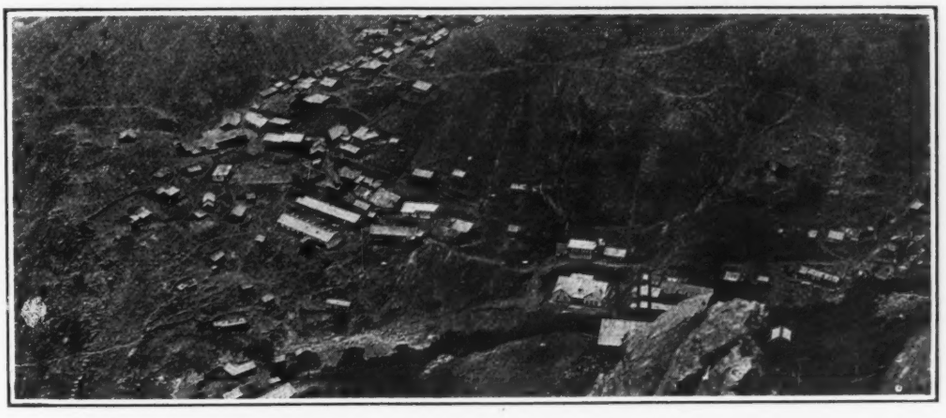
The two-compartment well-shaft is 650 ft. deep. The plant consists of two Prescott pumps, each of 950-gal. capacity, and two Worthington pumps, each of 1,322-gal. capacity. These deliver into two pipe lines, one of 10-in. diameter to supply domestic needs and the other of 20-in. diameter to supply the mills. The power that actuates the pumps is generated by two 7,500-kw. generators, driven by steam obtained from burning oil at the rate of four tanks, or barrels, per day. The water in the shaft rises within 18 in. of the pump station. Thte pumps operate against a static frictional head of 1,375 ft.

When the mine was started there was no water for drinking any nearer than the Gila River, 43 miles north of Ajo. Exploration by means of two drills found the water in the valley, and it was ascertained that whereas the depth of the water from the surface varied, the altitude was constant, indicating the existence of a water table. Without an adequate supply of drinking water it would have been impracticable to bring a large force of men to the mining settlement; and without plenty of water for metallurgical purposes, it would have been impossible to operate the large plants now at work. If engineering be the art of converting the resources of nature to the use and benefit of man, then the finding, pumping, and distribution of this ample supply of clear water is the most impressive of the many engineering features of the New Cornelia enterprise.

The total production of copper from June, 1917, to March 31, 1924, was 247,869,655 lb.

The care of the workers is shown by the schools, hospitals, and dwelling houses, built and arranged with such taste as to make Ajo famous as a mining center. The Mexicans live in a separate quarter. They and the native Indians constitute a large part of the force. All sorts of workers are given a fair chance. As Mr. Potter remarked to me: "We don't draw the color line; if a man has the ability, he gets the job."

To General Greenway, the manager, and to Mr. Potter, the plant superintendent, I am indebted for much courtesy and mental hospitality.



Part of the Camp of Dolores, Madera, Chihuahua, Mexico

The Smelter and Refinery of the Nichols Copper Co.

Sintering, Blast-furnace, and Converter Equipment Provide for Handling Coarse and Fine Ore and Matte—Electrolytic Refining Practice by Series System—Plant Largely Mechanicalized

By Edward H. Robie
Assistant Editor

THE COPPER SMELTER AND REFINERY of the Nichols Copper Co. is one of the oldest and largest plants of its kind in the United States and was one of the first two or three electrolytic refineries in the world. The company was originally known as the Nichols Chemical Co., one of its principal products being sulphuric acid made from burning pyrites. A matte was made which was shipped to Swansea, Wales. The copper company was formed about 1892, when the electrolytic refinery was built and provision was made for smelting custom ore. Since then numerous improvements have been made, particularly in the last year or two, so that now the plant is, in most respects, modern. Mechanicalization has been applied to many steps of the process and further labor-saving improvements are in prospect. As in all plants which have "just growed," the construction is not in all cases just what might be desired, but a wise application of modern principles in the handling of materials has been made.

The works are situated within the limits of Greater New York, at Laurel Hill, Long Island, on Newtown Creek, an inlet from the East River. This affords tidewater receiving and shipping facilities, though the water is not sufficiently deep to allow access of large ocean-going vessels. Their contents are usually reloaded on or from barges, simple but suitable hoisting equipment being provided on the pier, as is seen in the accompanying photographs.

The main unit of the plant is the electrolytic refinery, one of the two in the world operating on the series system. This has a capacity of about 25,000,000 lb. of copper a month; formerly as much as 40,000,000 lb. was produced, but the tanks are not now available for so large a tonnage. Should the occasion arise, however, they could easily be erected, as the floor space is available. In addition to the refinery there is a smelter of 5,000,000 lb. monthly capacity, consisting of a Dwight-Lloyd sintering machine, a blast furnace, a black copper furnace now partly dismantled, and four small converter stands; and a copper sulphate plant.

Ores and concentrates are received from many parts of North and South America, the company making a business of buying any copper-bearing material of this nature that may be available. The principal material received, however, is blister copper, this company at present receiving all or part of the output of Ducktown, Tennessee, United Verde Extension, Corocoro, Naltagua, Rio Tinto, and Katanga, among others. The Katanga property, in Africa, is now the most important source of supply. In addition, a small quantity of the purest scrap is purchased; exceeding care is necessary here to buy nothing with an appreciable content of lead or other deleterious metal, as the company has long been especially noted for the purity of its product—L.N.S. brand electrolytic copper—and considers it most important to maintain its reputation in this respect.

About two years ago, the ore-handling and sampling equipment was modernized. A clamshell discharges into a bin from which all or part may be passed through the sampler, whose capacity is about 800 tons per day. Successive cuts and crushings are made according to approved practice, the equipment being of the Vezin type. A Hum-mer screen separates the fine material, for sintering, from the coarse, which goes to stockpiles and thence to the blast furnace.

As no reverberatory furnace is used, the fine material must be sintered. Eight or ten years ago a reverberatory furnace was erected, but it was not a success. A standard Dwight-Lloyd sintering machine, with a capacity of about 100 tons per day, is in constant use. One feature of this installation is the circular rotary mixing table directly above the machine, an idea of which may be obtained from the illustration on page 292. Water sprays are used to provide the moisture necessary for even ignition and a solid cake, and baffles suspended above the table assure a proper mixing. Stationary scrapers at the side project over the edge of the revolving table, removing the mixed material, which then falls directly on the grates. Another feature of this installation, and one that has been very satisfactory, is the driving mechanism, also shown in another photograph. A variable-speed Westinghouse motor drives a Jones spur-gear speed reducer, the sintering machine itself being driven by a Jones worm gear. The pallets may be driven at any desired rate between 18 and 42 in. per minute, according to the character of material to be sintered. A horizontal oil-fired ignition chamber of the usual form is provided. As in most of the Eastern smelters, no more sulphur is driven off than is necessary, the only function of the machine being to provide a sintered charge of concentrates, flue dust, and screenings, for the furnace.

Most of the blast-furnace charge is taken from stockpiles situated near the furnace building. The problem of getting this material to the furnace charge floor efficiently has been a very real one; it has been satisfactorily solved by the following method, which could well be adopted at other plants where modern conveniences in construction are not present: Just outside of the furnace building a steel-lined concrete pit about 21 ft. long, 4 ft. wide and 6 ft. deep has been constructed, the surrounding ground between the pit and the stockpiles being given a concrete floor. Two-wheeled hand buggies are loaded at the stockpiles, wheeled to the pit, and overturned into the blast-furnace

charge car which has previously been lowered into the pit. Coke is placed on the bottom, and the sinter and cold material are loaded above. The car is then hoisted vertically until on a level with the charge floor, following which it is drawn along an overhead rail to the charging position. The photograph shows the car being raised. This is done by a Lidgerwood double-drum electric hoist, one drum being used to raise the car and the other to pull it to the furnace.

Now, by this method of charging, all of the material goes into one side of the furnace, a condition which caused some trouble until the baffles shown in the accompanying illustration were devised. One charge is dumped freely into the furnace, and then the baffles are slipped into place, so that when the succeeding charge is dumped it is thrown against the opposite wall. This device appears somewhat crude, and it may be improved, but the furnace works well. Probably a lead furnace would be more particular as to how it was fed.

The furnace is 39 ft. long, 6 ft. wide at the charge floor and 4 ft. at the tuyères. These last are 4 in. in diameter, and supplied with air at from 20 to 40 oz. pressure, depending upon how fast it is desired that the furnace should run. About 11 per cent of coke on the charge is customarily used. There is a cast-copper water-cooled breast jacket in the furnace, and also a cast-copper launder for the slag-matte stream to the settler. This launder is water-cooled by the inclusion of iron pipes in the casting. Tap holes are provided near the base of the breast jacket, from which metallics are occasionally tapped.

Novel Method of Slag Disposal in Bottom of Sea

The oval settler is lined with magnesite brick; the inside dimensions are about 14 ft. by 8 ft. by 4 ft. Arrangements are made for granulating the slag or casting it on the pans of a conveyor which discharge onto barges, no slag-dumping space being available at the plant. The barges are towed out to sea, the slag being dumped by opening gates in the floor. The coarse slag cast in the pans is placed on the bottom of the barge, and granulated slag piled on top; it is more economical to granulate all of the slag, but the barge gates are not tight enough to hold it. The slag runs about 0.5 per cent copper. The furnace matte is of extremely high grade, averaging about 59 per cent copper.

A twenty-five-ton Niles crane picks up five-ton ladles of matte and carries them about 50 ft. to the other end of the building to the four converters. These are of the small horizontal type, familiar in the old acid practice, but the lining consists of a layer of magnesite on a backing of magnesite brick. The matte is of very high grade and therefore each ladle is blown direct to blister copper with one slag blow and one copper blow, and no special care is necessary to keep the lining from overheating. Under these conditions difficulty is experienced in preventing converter shells from filling up, due to lack of heat in the matte. Wirebar and anode furnace slag is used for flux, and the blast is about 8 or 9 lb. pressure. The converter slag is quite viscous—so much so as to necessitate the removal of all or a large percentage by hand rabbling. It is allowed to solidify in pots, which are then dumped, and the slag, containing about 7 per cent copper, is charged to the blast furnace.

A black-copper furnace stands close to the matting furnace. It has not been used for some time, and the jackets have been removed, but it has done excellent work on oxidized ores when they had to be treated.

Blocks of blister copper are cast in movable molds running under the converters. They are dumped between the rails and air-cooled. These are then picked up by a crane, piled on cars, and transported to the anode furnaces. Every tenth car is routed to the drill room for sampling, incoming shipments of blister also being sampled. The cars of foreign blister pass over a scale just before entering the drill room, and then most of them pass over a straight track directly on to the anode furnaces. Those to be sampled are switched off to the side of the drill press, taken off and drilled, reloaded on the opposite side of the drill press, and switched back into the main line to the anode furnaces —a most efficient arrangement.

More Than Usual Care Exercised in Anode Department

Ten oil-fired anode furnaces are available; seven are now in use. They have silica-brick walls and roofs, and silica-sand bottoms, each being equipped with waste-heat boilers overhead. Some improvements are in prospect here, the management having approved preliminary plans for separate furnaces for melting blister and for refining anodes. Out of the present furnaces, about 180,000 lb. of copper can be ladled, a twenty-four-hour cycle being maintained. From 1 to 4 p.m. is the charging period; 4 to 11, melting; 11 to 3 a.m., blowing and skimming; 3 to 7, poling; 7 to 1 p.m., ladling out the finished copper into the anode molds. Blowing is done by ¾- or 1-in. iron pipes, using 25 lb. air. Three pipes are used at once; the ends burn off rapidly when submerged in the bath, and, so far, experiments in protecting the pipe have not been successful. Skimming is done through one front door, with hand rabbles, into cast-iron pans holding 2,000 lb. each. These skimmings are weighed, sampled, and dumped, subsequently being charged to the blast furnace or converters.

Fresh-cut, green, hardwood poles from Long Island are used for poling, the limbs forming the material for brands thrown on the bath.

A circular casting wheel is provided for each furnace, in the middle of which stands a man operating a long-handled cast-steel ladle holding 90 lb. He withdraws this from the furnace and pours it into water-cooled cast-iron molds, forming anodes 12 by 54 in. and ⅜ in. thick. Casting is at the rate of fifteen tons an hour. The anodes are removed by hand, while red hot, and piled on a car.

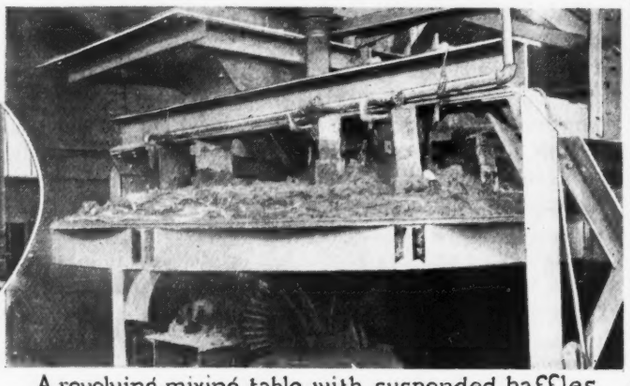
Extreme care is used to get the copper in proper shape so that a smooth casting can be made for the series electrolytic treatment to follow, as rough anodes give a poor base for the cathode copper.

Special care is also given to the molds, which, following each cast, are treated to a dash of finely ground silica (98 to 99 per cent through 200 mesh) suspended in water. This is applied by a man with a kalsomine brush.

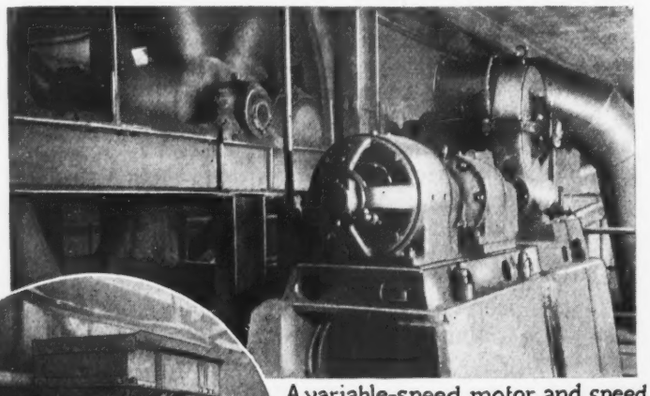
The anodes are air-cooled to a warmth bearable to the hand, removed to a flat bed, where they are straightened by a rap or two with a hammer if need be, 1¼ in. round holes punched in the ears for suspension in the tanks, and sprayed on one side with a resinous soap emulsion. As the cathode copper is deposited right on

THE NICHOLS COPPER WORKS
Laurel Hill, N.Y.

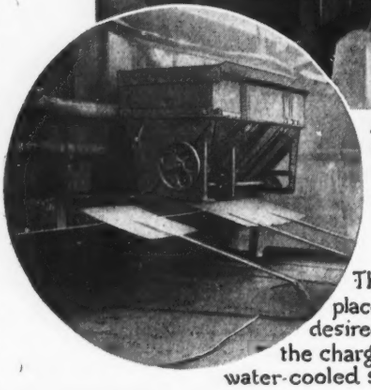
These bars of blister being unloaded from the barge are from Katanga. Some are stamped UMP, others UMC and UMX, though what the P, C and X mean is a mystery



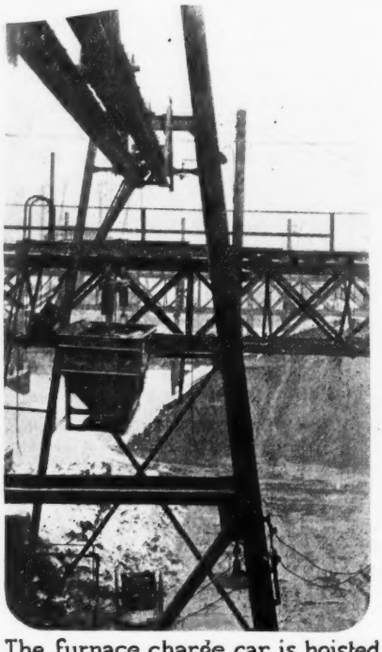
A revolving mixing table, with suspended baffles, prepares the charge for sintering right at the machine



A variable-speed motor and speed reducer makes an unusual but satisfactory drive for the sintering machine

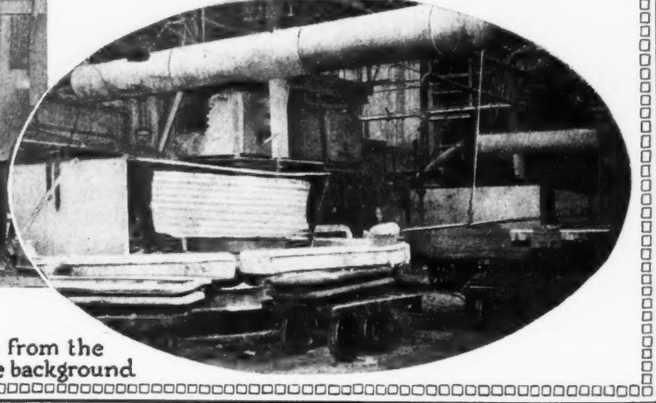


The blast-furnace charge car in place; the baffles can be inserted when desired, for alternate charges, and throw the charge to the opposite side. Note the water-cooled steel top of the furnace

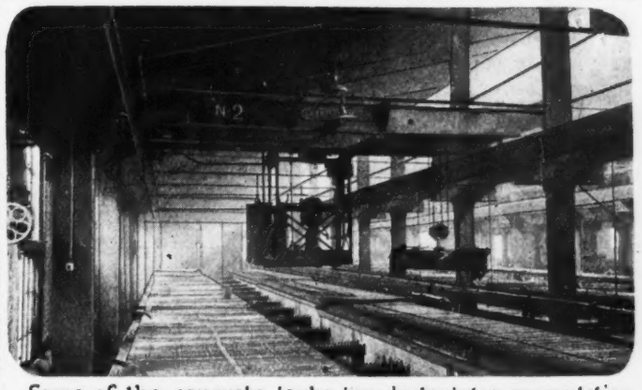


The furnace charge car is hoisted above the loading pit and pulled to the charge floor. Stockpiles in background

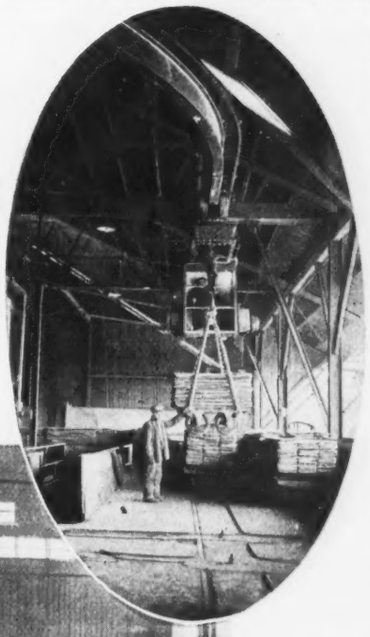
Four basic converters treat a 59 per cent matte.



The cast anodes are removed by hand from the molds and piled on a car shown in the background

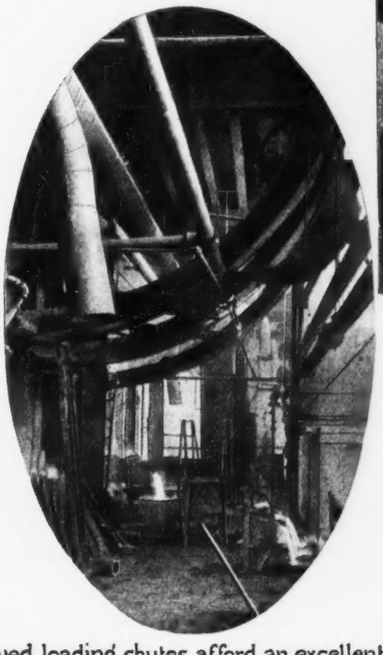


Some of the concrete tanks for electrolytic precipitation. The crane handles electrodes in racks of 85 at once



A monorail system brings cathodes to the charge floor of the wirebar furnace, where they are slid into the furnace

Lowering cathodes on the floor for stripping. Piles of the anode scraps can be seen to the right



Curved loading chutes afford an excellent charging means for the new wirebar furnace. The light-colored pipe is a ventilating duct.

Twelve wirebars are cast at once with the new equipment at No. 3 furnace

Gasoline tractors afford a satisfactory solution of all surface transportation problems

Wirebars are unloaded into barges and are later transferred to ocean-going vessels in New York Bay

the anode, this painting is necessary to facilitate subsequent stripping.

The prepared anodes are assembled in racks by an air lift and hung in racked cars. A Baldwin-Westinghouse five-ton storage-battery locomotive shoves these cars to the tank room.

Enlarged Tanks, of Concrete, Now Built

The tank house contains 412 units, in most of which 510 anode plates are suspended, five abreast. Each rack of anodes is made up of eighty-five plates, so that the five-ton Columbia crane used for the purpose requires six "takes" to fill a tank. After filling, the tank being empty of electrolyte, the plates are carefully adjusted so as to hang parallel and at the same distance apart, wooden spacers being used to preserve the proper interval at the top of the tanks, and the hang of the plates being adjusted by means of the small copper links by which they are suspended. When all is well, the electrolyte is turned in and precipitation allowed to continue for twenty days, or until the proper number of ampere-hours are registered, recording instruments being used for each unit. The cathodes, which have then replaced the anodes, are withdrawn by the crane, six drafts at a time as before, loaded into rack cars, and taken to the stripping room. The slimes in the tank are removed by hand—a stage of the process which has not yet been mechanicalized—roasted, leached for copper with sulphuric acid, dried, sampled, and shipped to another refinery for recovery of gold and silver.

Until a year or two ago, all of the tanks were made of wood, with a mastic coating, and when loaded by hand had a life of about seven years. Recently, concrete tanks have been built in two aisles of the tank house, and they promise to be much more satisfactory, having an indefinite life—with no leakage such as is caused in the wooden tanks by stresses and strains set up by successive loading and emptying. One concrete tank replaces two wooden tanks, and as the space between the two wooden tanks is also utilized, the concrete tank is $\frac{1}{6}^{3}$ the size of the wood and takes a proportionately greater charge, also requiring a proportionately greater voltage from head end to tail end. Electrolyte is distributed by lead pipe running about 8 in. above the tops of the tanks. All storage pits are beneath the floor; from these, the electrolyte is pumped by Worthington lead-lined, variable-speed electrically driven centrifugal pumps. Steam coils of lead are used for heating the solution, which is kept at a temperature of about 122 deg. F. Mastic lining, formed of a blend of asphalt and blown oils, is applied hot to the interior of the tanks, and built up to a thickness of approximately $\frac{3}{4}$ in.

About four gallons of electrolyte per minute is in circulation in each of the smaller tanks. This contains around 17 per cent of free sulphuric acid and 2.8 per cent copper.

Most electrolytic refineries operate on the multiple system, the current passing from one busbar to one anode, through the electrolyte to one cathode formed on a starting sheet, and then out to a busbar on the other side of the cell. In the series system, used at the Nichols plant herein described and at the American Smelting & Refining Co.'s works in Baltimore, the current enters the cell through a lead grid or by the copper anode at the head end; the copper is removed from the back of one anode and deposited on the face of the succeeding anode, which thus becomes the cathode, and so on to the end of the cell, no expensively made starting sheets being required, no busbars along the side being necessary, and the lugs at the top of the electrode requiring to be only of sufficient size to support the weight of 90 lb. The elimination of so many electrical connections cuts down the power consumption materially; it also eliminates inspectors required in a multiple system for watching these contacts. In time the back of the anode is all eaten away, or substantially so, and the plates are then removed; if this were not done, the current would go on plating out copper from one cathode plate to the next, and the power consumption per unit of cathode copper produced would rise.

Improved Series System Now More Flexible

A great deal has been done at this plant very recently to modernize the series system, mechanically and metallurgically. Cranes have been installed throughout the tank room and stripping room, and many other improvements made, doing away with much of the hand labor formerly employed. Further mechanicalization is contemplated. Metallurgically, experimentation and actual practice have revealed that the series system as practiced at Laurel Hill can treat blister copper of much higher impurity content than was formerly believed to be possible; it is in fact applicable to the output of any mine or smelter producing copper of ordinary modern purity unless very high in silver. It possesses distinct advantages in savings in power consumption, starting-sheet production, "sheet-straightening," smaller amount of anode scrap, and lower initial construction cost and copper tie-up, resulting in lower interest, depreciation, and amortization charges—note the small size of the necessary electrical conductors in the photograph. Partial offsets to these advantages are a slightly greater anode preparation cost, the expense of removing anode scrap from the cathodes, and a somewhat higher silver loss.

Where reasonably smooth cathodes are desired, for shipping as such, the current density is kept around 18 amperes per square foot; otherwise about 22 is used. The details of handling the electrolyte cannot be described now, but it suffices to say that marked improvements have been made in the last year; the employment of organic addition agents in the electrolyte and other variations in practice have permitted the use of anodes much higher in impurities than formerly. The electrolyte is purified by the usual methods, a copper sulphate plant forming part of the purification system.

Wirebar Furnace a Model

In the stripping room, the racks of cathodes are picked up by five-ton cranes and the plates piled horizontally on the floor as shown in the photograph. Two men work on each carload. A bar is introduced in the lugs of the cathode, and the anode scrap peeled off by hand. As what remains of the anode is very thin—in places there is no anode at all—it will not come off clean, so an adz is used to coax off the last vestiges. Any anode copper left on the cathode decreases the purity of the finished product and means loss of the contained precious metals. The painting of the anode before it goes to the tank house facilitates the stripping, as has been mentioned. The stripped cathodes are piled by hand on cars, and elevated by an electric hoist and

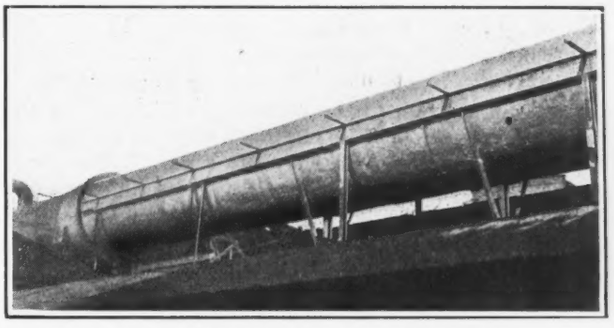
monorail system to the feed floor of the wirebar furnaces.

A new furnace, known as No. 3, has replaced two others, now used as spares. It is a model, and the largest of its type in the world, having a capacity of 750,000 lb. per day. Oil firing is used, and a 1,250 hp. Keeler waste-heat boiler is superposed. The walls are of magnesite brick, about 20 in. thick with a silica-brick roof and a silica-sand bottom. The charging chutes are curved, as shown in the photograph, four being on one side of the furnace and three on the other, with two on the front end of the furnace. A twenty-four-hour cycle is rigidly maintained, only four hours being required for casting, less than two for charging, and the rest for melting, skimming, and poling.

The course of the molten metal from the furnace may be traced in the illustration. Twelve wirebars are cast at once into molds carried on a straight-line casting machine of local design. The molds are washed with a mixture of bone ash and water. The bars are brought out of the wash water by a conveyor, made into drafts by hand, and laid on inspection tables, where they are carefully examined for defects. The percentage of rejects is very small, owing to the modern methods and equipment used. The bars are then weighed, a carload at a time, and taken to railroad cars or to barges for shipment.

The transportation problem throughout the plant has been pretty well solved. Shepard crane and monorail equipment is used for practically all of the overhead work, except as otherwise noted, and Fordson tractors are used for surface transportation. These tractors are equipped with rubber tires and a bumper on the front, so that they are useful for pushing as well as pulling, either for cars running on tracks or on the ground. They are much more satisfactory for this work than was the storage-battery equipment which they displaced, being at all times ready for service; a fleet of eleven of them is now maintained.

A large percentage of all the power is generated from the waste-heat boilers attached to the various furnaces, there being only one or two direct-fired boilers used as a rule. Waste gases are conducted through an extensive flue system to a central brick stack 300 ft. high, the dust being allowed to settle out by gravity, and removed through hoppers in the various flues. Many of the flues are coated with gunite, which has proved an efficient method of prolonging their life and preventing loss of heat.



One of the flues, coated with gunite

A word as to the personnel. F. E. Lee is works manager, and W. H. Hubbard, assistant general superintendent. M. H. Merriss, assistant to the executive vice-president, J. B. Beaty, acts as contact man between the New York office and Laurel Hill on all metallurgical matters. It is through the kindness of C. W. Nichols, president of the company, and the courtesy of these men and the department heads, that this article has been made possible.

Crystal Copper, of High Electrical Conductivity

The following editorial, discussing the laboratory production of large crystals of copper, recently appeared in *Electrical World:*

"The two great metals of the electric art, iron and copper, present many contrasts, but none perhaps more marked than that of the relative permanence and fixity of their respective properties. Electric steel presents a wide range of magnetic properties, and the more important of these properties have been steadily improved under study and experiment as the years have passed. Copper, on the other hand, shows little or no variation, is used for one property only over a wide field of application, and long years of acquaintance with it and attention to its refinement have resulted in improving its conductivity only a fraction of 1 per cent. In fact, copper has always been just copper, and the electrical engineer has been glad to feel that there is at least one tool of his trade not subject to continual change.

"But apparently even copper has yielded to the restless probe of modern research, and now comes the really astounding announcement of copper with a conductivity 13 per cent greater than present standard values, and so greater than that of silver. The improvement is due to its crystalline state. The possibility of producing crystals of copper was first shown by Professor Bridgeman, of Harvard University, and the present announcement comes from Dr. W. P. Davey, of the General Electric Co., who has succeeded in forming copper crystals six inches long by one inch in diameter, the method being slow heating and cooling in the electric furnace. It is not so remarkable that an increase in conductivity should have been found, the crystals once formed, for it is well known that many crystals have quite different properties in different directions through their structures. Many examples are found in optical phenomena, and dielectric properties show similar differences. So far the achievement is in the obtaining of the crystal rather than in the increased conductivity.

"Crystal copper has several interesting properties. It can be bent without effort, but it cannot be straightened again. This is due to the fact that the distortion upsets the balance of the atoms, and they readjust themselves into the very small crystals of ordinary copper. The specimen passes over into the latter form and then shows all its properties. Dr. Davey showed by X-ray examination that his specimens are each one big crystal with the atoms arranged in regular rows, and that one of the axes of the cubic form in which copper crystallizes runs through the long axis of his single crystal six-inch rod. It was along this axis that the increased conductivity was found, and to show that the increase was due to the crystalline form, the specimen was hammered and then annealed so that its uniform structure was destroyed. Its conductivity was then found to be that of ordinary copper. Commercial copper was used for making the specimens.

"The production of commercial copper of this increased conductivity would have consequences of far-reaching importance, as may readily be imagined. The reduction in cost alone would greatly increase the number of economically possible enterprises. Several press announcements have promised an early commercial production of the metal. In view of the present data, however, small credence can be given to these reports. All accounts indicate that crystal copper is extremely sensitive to working or handling of any kind, and this would seem to preclude its use in manufacture. But naturally we shall wait expectantly for the results of the further study and control of the properties of 'supercopper.' "

Discussion

Treating Pilbara Copper Ore

THE EDITOR:

Sir—The "London Letter" in your issue of Oct. 4 contains an allusion to the treatment of the ore of the Pilbara Copper Fields, Ltd., (the Whim Well mine) by the Perkins ammonia process. It says, "It had been hoped that Minerals Separation had found a process that would treat" the ore. This seems to infer that difficulty had been experienced in finding a process to treat the ore successfully. It alludes also to the outlay required by the treatment, which is inferred to be abnormally high.

These remarks may cause misconception regarding both the ore and the process. To correct any such ideas, and because further details regarding the subject may be of interest, the following comment is submitted:

The process was concerned only with the oxidized ore of the upper levels, which is nearly wholly in the oxidized form, the great bulk being in the form of carbonate. It is evidently amenable to any of the established leaching methods applicable to oxidized copper ores. It has been proved to be readily amenable to leaching by (1) dilute sulphuric acid, (2) the Pechey process, (3) the process installed at Mount Hope, New South Wales, (4) the metallic-contact (Copper Separation, Ltd.) process, (5) the treatment evolved in western United States by the use of "pyrite filters," as well as (6) the Perkins ammonia process.

Tests indicate more than 95 per cent as soluble in dilute sulphuric, but the cost of the acid precludes No. 1, and No. 2 and No. 3 are sulphurous acid gas treatments applied in a continuous circuiting of solution, the second requiring ore heaps. No. 4 requires fine grinding, the pulp being heated and agitated with finely divided (sponge) iron and a solution containing ferrous sulphate and a suitable chloride. The reaction—removing the copper from the ore and precipitating it as free metal in the pulp—occupies only a few minutes. The copper is then recovered by flotation, but it can be recovered by elutriation. No. 5 has been applied generally to heap leaching and consists of continuous circulating of solution through ore, pyrite filters suitably placed and manipulated, and iron. I described these processes more fully in your columns about a year ago. Joseph Irving has described No. 5 in *Mining Journal-Press*.

It is not just to the ammonia process to say that the outlay entailed is excessive, without giving some of the particular reasons. The situation of the Whim Well mine makes fuel costly, transport costs being high. The fuel requirements for the treatment are large. But for this the operating costs would be very favorable. The requirements noted entail special sea and land transport and handling arrangements for crude oil, thus increasing the capital outlay. The local conditions also are unfavorable to a process consuming much water and requiring water cooling on a large scale. Water has to be pumped ten miles, and the climate (being often very hot and sometimes humid) greatly increases the problem of cooling. In many places these conditions would not apply. Bwana M'Kubwa is mentioned in this connection. There, probably, fuel is cheap and water may be abundant.

In comparing the treatment with others, it should be borne in mind that it produces the copper in the refined form ready for market. Allowing for this and for the above-mentioned special factors, the work done at Whim Well does not indicate an unusually large outlay for mines differently circumstanced.

Fifteen per cent is quoted as the proportion of fine material to be removed. This is conservative, and there is good reason to expect that this would be reduced in practice. This ore, however, is not very favorable for tank leaching (whether by the Perkins or any other process). It contains a fairly large proportion of clayey matter. A sufficiently quartzose ore would require the removal of no fine material. Tests on the ore of the Mons Cupri mine (3 miles south of Whim Well) indicated that no removal was required for it. Probably the Bwana M'Kubwa ore is similar. From what I have heard of Bwana M'Kubwa conditions, I assume that the ammonia process should suit them excellently.

A point of interest is that the heating and reducing of the copper salts to the metallic state evidently improves the percolating qualities of ore, these constituting, of course, an important factor in tank leaching. Other factors being the same, the same coarseness of crushing and handling the Whim Well ore would require the removal of less fine material to permit of good percolation with the Perkins process than with others.

The choice of treatment for Whim Well undoubtedly is between No. 4, the metallic contact, and No. 5, heap leaching with pyrite filters. No. 4 has the advantage of rapid extraction and therefore of small plant outlay. It, however, has not yet been proved commercially. Its fuel consumption is not excessive and its water consumption is low. No. 5 has the advantage of very low fuel consumption, of simplicity (it can be made indeed nearly fool-proof), and the fact that the climate would assist the treatment and that the salt or brackish water, the most readily obtainable, assists, by virtue of the contained chlorides.

Those controlling the metallic-contact process are now completing the erection of a plant at Kundip (on the south coast of West Australia), and treatment is expected to be started soon. The ore there contains copper and gold, both of which the process recovers, the gold accompanying the copper precipitate. If the work at Kundip is successful, the intention is to erect a plant for that treatment at Whim Well. Otherwise it is probable that pyrite-filter heap leaching will be adopted.

H. R. SLEEMAN.

Perth, Western Australia.

News of the Week

The Mining News of ENGINEERING AND MINING JOURNAL-PRESS is obtained exclusively from its own staff and correspondents, both in the United States and in foreign fields. If, under exceptional conditions, material emanating from other sources is published, due acknowledgment and credit will be accorded.

Summary

THE Banking and Currency Committee of the House of Representatives has approved the bill authorizing the purchase of 14,500,000 oz. of silver at $1 per ounce. The proposed measure has already received the approval of the Senate.

Philip S. Smith and his associates mapped 20,000 square miles in their recent explorations above the Arctic Circle.

A new mining camp in Nevada, Gilbert, is experiencing a boom, though only one carload has so far been shipped.

United Eastern sues Tom Reed Gold Mines Co. for unlawful extraction of ore.

The International Smelting Co. has leased part of the Yankee mine, in Utah, and will develop its deeper workings.

A tax of 4 per cent on the gross value of all ores, "produced, and sold, and exchanged, and marketed," is provided in a bill which has been introduced in the Idaho Legislature.

Output of the Consolidated Mining & Smelting Co. should be materially increased by expansion of facilities for the reduction of lead and zinc ores.

Mount Lyell mines, in Tasmania, are being operated profitably, despite the low price of copper.

Shipments of 40 per cent lead ore are being made from the old Chloride district in New Mexico.

Empire Zinc Co., a subsidiary of the New Jersey Zinc Co., has leased the Hedley holdings in New Mexico.

A rich strike is reported to have been made in the Republic, mine near Caliente, Nev.

El Tiro Copper Ships Regularly from Silverbell, Ariz.

Six Per Cent Copper Ore Goes to Hayden Smelter—Cost 10.81c. Per Pound

El Tiro copper mine, the largest shipper of high-grade ore in the southern Arizona and the second largest shipper of any kind of ore in Pima County, sent 6,784 tons of ore to the smelter during the last seven months of 1924. The average grade was 9.33 per cent copper, ranging from 6.56 per cent to 12.25 per cent copper in carload lots. The gross value of production for seven months was $167,971.49, at an average value of 13.2c. per pound of copper. Of this amount the smelter received $71,085.55; the railroad, $20,175.44, and the mine itself netted $76,669.94.

All costs, including smelter, freight and mine charges, except taxes, totaled 10.81c. per pound, leaving a profit of 1.81c. per pound for the seven-month period above noted.

Starting on Jan. 1, under a new contract, El Tiro began production of 100 to 150 tons per day, of approximately 6 per cent ore.

The development of the mine during the last year has been encouraging, and profits from present operations are largely being used in development work at greater depth.

The El Tiro property is situated on the Arizona Southern Ry., and it is admirably equipped with ample machinery for heavy mineral production.

A large tonnage of 3 to 4 per cent ore is being steadily opened up in this mine, and in another year a mill will be necessary for the handling of that grade of materials. Leaching and flotation are being considered.

The total production of El Tiro since Jan. 1, 1919, is approximately 7,000,000 lb. of copper. Since it resumed shipment last May 1 it has not missed a single week in the shipment of a trainload of ore to the A. S. & R. smelter at Hayden. Percy Williams, trustee for the bondholders, who control the mine, is manager.

281 Miami Copper Gardeners Ready to Work

MIAMI Copper's 31-acre garden tract at Miami, Ariz., has been divided into 281 plots, which are soon to be allotted to company employees for the coming season. Allocation of the plots will be made according to an impartial drawing of the applicants' names. Use of the ground, plowing, water for irrigation, and the advice of a horticulturist are provided without cost to the permittee by the company. Records kept over a number of years show that the value of the crop of each garden, on an average, is approximately $200, provided it is consumed by the grower himself.

Gilbert, New Nevada Camp, Is Surveyed and Mapped

Much Activity in Company Promotion—Active Development Expected This Spring

The new camp of Gilbert, situated about 20 miles northwest of Tonopah, Nev., continues to be the center of interest for mining in Nevada, and great activity is expected in the spring. Claims have been staked for several miles around the original discovery, and surveying of claims is under way, with five surveyors already on the ground. A preliminary district map has been published by F. M. Rapp, mining engineer of Tonopah, and is being distributed extensively. About fifty houses and tents have been erected and the camp is rapidly taking on the aspect of a boom. The district is unique in that there are two companies organized and financed, several others in process of organization, and many tentative agreements entered into—and only one carload of ore shipped to date. However, with weather conditions improving, it is expected that more energetic prospecting and development work will be done.

A new discovery was made during the last week on the Homestake ground, to the southeast of the original discovery.

The Gilbert Last Hope Gold Mining Co. has consolidated its holdings with the Mammoth group, and formed the Gilbert-Mammoth-Last Hope Mines Co.

International Smelting Co. Leases Part of Yankee Mine

Activity Throughout Tintic District—Old Mines Rejuvenated—North Standard Works 850 Level

The International Smelting Co. is reported to have entered the Tintic mining district at Eureka, Utah. The smelting company, it is said, has taken a five-year lease on the eastern part of the old Yankee mine, and plans to develop adjoining property, which it is understood to have acquired control of, to the north, east and west through the deep workings of the Yankee. The smelting company will equip the Yankee shaft with hoist and equipment, and will start crosscutting to the east from the 2,000 level of that property to develop the Addie and other ground adjoining.

Everywhere throughout the district there is activity. The older and tried mines are working and shipping heavily, and opening new ore. The Chief Consolidated has completed and is operating a new milling plant, making possible the exploitation of all classes of ore from the property. Older mines which have gone through a period of inactivity are being again brought to productivity. A find of importance is reported at the Mammoth, 100 ft. below the 1,500 level, over 2,000 ft. distant from old stopes, and about 3,000 ft. to the north of the shaft, so that it is thought possible that a new ore channel (possibly the continuation of the Plutus ore channel) may have been found. It is stated that the new ore is more than 30 ft. in width, and that it carries 60 per cent lead and 15 to 25 oz. silver.

The Mammoth has lately been shipping four to five cars of ore weekly. Of the newer properties, the Plutus mine of the Chief Consolidated has been a shipper for some time. Lately the Apex Standard has entered the producing class. The Mountain View, a consolidation of the Uncle Sam and May Day properties, has acquired the western part of the Yankee, which retains the right to the use of its shaft jointly with the International, and has leased a block of the Colorado Consolidated; and it has the right to work from the No. 4 shaft of the Colorado, which is the deepest shaft at that property. There are forty men working on the Mountain View holdings.

The Tintic Davis Mining Co. (owning property near the Chief), the Letis Tintic, and Paymaster are planning increased activity. At the North Standard, in the neighborhood of the Tintic Standard, work is being done on the 850 level, where the ground shows increased mineralization.

Kay Copper Co. Reports Ore

The Kay Copper Co., operating at Canon, Ariz., has reported its second strike of ore within recent weeks, the new discovery being made on the 1,202 south drift, which has advanced more than 10 ft. into a body of ore containing chalcopyrite. Assays as high as 11 per cent copper are reported to have been obtained.

Four Per Cent Gross Value Tax Proposed in Idaho

Mining men throughout Idaho are greatly exercised over the introduction of a bill in the legislature by Senator H. Reineke, of Canyon County, which provides a tax of 4 per cent of the gross value of mine production. The bill reads.

"Every person, corporation or association engaged in the business of mining of gold, silver, lead, zinc or other ores in Idaho shall pay a tax equal to 4 per cent of the gross value of all such ores produced and sold, exchanged, marketed or otherwise disposed of.

"Every such person, corporation or association producing and disposing of said ores, or any of them, shall keep a true and correct record of all such production, including the amount of ores actually produced and sold for each day in the year, and such records shall be open and available to assessors, and the assessor of the county in which such ores are produced shall assess the same according to the value thereof.

"Every person, corporation or association in the state producing any of the ores mentioned on or before Feb. 1, 1926, and annually thereafter, shall file with the state board of equalization under oath a true record of ore production covering the preceding calendar year and shall furnish to said board such other information touching upon the production of any such ore as the board shall require."

United Eastern Sues Tom Reed for $70,948

The United Eastern Mining Co., of Oatman, Ariz., has started suit in the Superior Court of Yavapai County against the Tom Reed Gold Mines Co. The present action is an aftermath of the litigation which occurred between the two companies several years ago. The first suit was brought by the Tom Reed company for possession of the Big Jim claim, at Oatman. The decision of the lower court in this case ordered a division of the orebodies which gave the United Eastern possession of the main Big Jim vein and gave the Tom Reed company ownership of a smaller branch vein. The decision was upheld by the Supreme Court of the United States. In the recently filed suit the United Eastern alleges that the defendant company wrongfully extracted ores from the Big Jim claim to the value of $70,948.

Prince Con. Pumping Plant at Pioche in Operation

The new pumping plant at the Prince Consolidated mine at Pioche, Nev., is working satisfactorily. The water level is being steadily lowered and mining of the richer developed beds will soon be resumed in the Virginia Louise mine. The two properties now are being operated under the same management. Stock in the Prince Consolidated has risen on the Salt Lake Exchange from 5c. per share to 31c. in the last two months.

New Automobile Highway Serves San Dimas Mines

Hydro-electric Development Is Planned to Supply Power for Mines and Other Industry

The completion of an important link in the plans of San Francisco capitalists to develop hydro-electric power reserves for electrifying the State of Sinaloa, Mexico, was celebrated recently at San Ignacio, Sinaloa, when Acting Governor Diaz officially opened the 30-mile newly built automobile road connecting Dimas Station with the above-mentioned town.

Though built primarily to facilitate the transportation of supplies and bullion, respectively, to and from the mines of the San Dimas Mining & Milling Co.'s properties, just over the state line at San Dimas, Durango, the ultimate purpose of the new road is to prepare the way for carrying forward construction of the great power project.

The recently completed road, although built under state supervision, was financed by the San Dimas Mining Co. under an arrangement whereby certain taxes of the company will be suspended for a number of years. From San Ignacio, terminus of the auto road, a 100-mile mule trail must be traversed to reach San Dimas, the location of the company's mines and near the site of the proposed power sources.

The electrical energy to be developed by the new project will not only furnish power for all the mining properties of a wide district, but will also provide power for lighting the principal cities of the West Coast and for manufacturing.

The properties of the San Dimas Mining Co. were opened thirty years ago by Dan Burns, of San Francisco, and have been in continued operation since that date. They consist of the Mexican Candalaria, Estaca, Pilar, Rosario, Contra Estaca, and Guadaloupe properties. Charles Dunphy, of San Francisco, heads the company.

U. S. Steel Leases Zinc Lands

Leases on several thousand acres of land in the vicinity of Peoria, Okla., have been taken recently by the United States Steel Corporation, through that corporation's representative here, Floyd Weed. Drill rigs have been assembled.

Peoria is situated east of Picher, near the Kansas state line and even closer to the Missouri line. It is one of the oldest mining camps in the Joplin-Miami district, though it never has been a heavy producer. Indians are said to have mined lead near Peoria years ago.

The Steel Corporation has been investigating this district for many months, and, it is believed, plans ultimately to produce much of the ore used by the Edgar Zinc Co., one of its subsidiaries.

Will Sink Blue Bell Shaft

The shaft of the Blue Bell mine, in the Mayer district of Arizona, is to be sunk to the 1,500 ft. mark and an extensive program of development is planned, according to G. M. Colvocoresses. The shaft is now down 1,350 ft.

Plant Expansion Should Increase Output of Consolidated Mining & Smelting Co.

Lead and Zinc Capacity at Trail Reduction Works Being Enlarged—Sullivan Mine One of World's Biggest Lead-Zinc Producers —Public Would Like Ore-Reserve Estimate

By A. B. Parsons
Assistant Editor

WITH the capacity of its reduction works at Trail largely increased, with its Sullivan concentrator working at full capacity, and with assurance that adequate electric power will be available when needed, the year 1925 should be a profitable one for the Consolidated Mining & Smelting Co. of Canada, leading mining and smelting company of British Columbia.

The accompanying table, giving the production of the smelter at Trail during recent years, shows the phenomenal growth of the enterprise. In addition to the lead, zinc, and silver indicated for 1924, the smelter also produced 27,000 oz. of gold and 1,400,000 lb. of copper.

Production from Trail Smelter

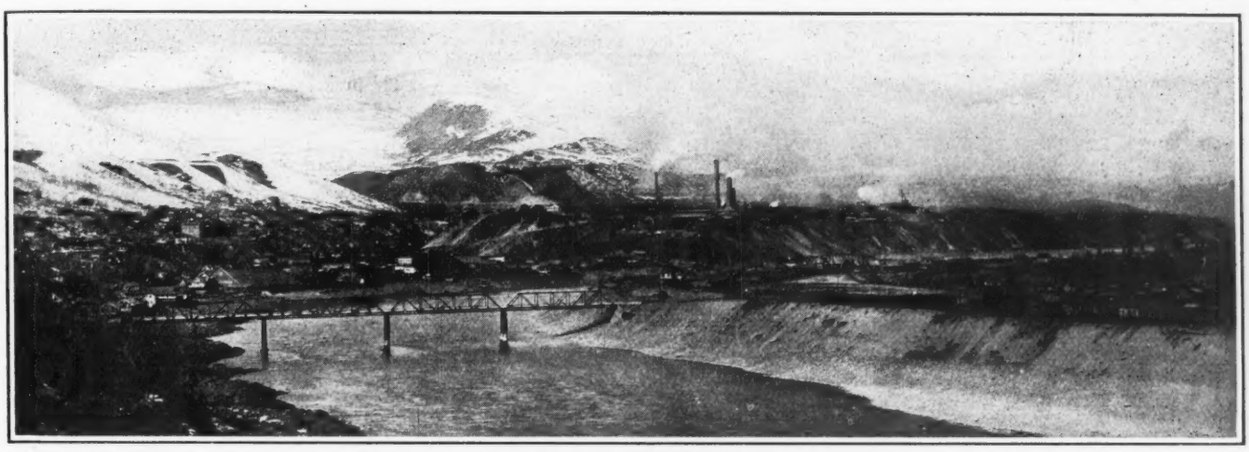
Year	Lead Pounds	Zinc Pounds	Silver Ounces
1920	26,474,652	36,995,394	1,097,930
1921	57,683,328	52,998,159	1,198,114
1922	84,352,017	55,564,960	2,116,351
1923	95,941,200	60,050,951	2,960,714
1924	161,900,000	(a) 55,000,000	3,935,000

(a) In addition about 50,000,000 lb. of zinc was shipped to Belgium and Great Falls, Montana, in the form of concentrate.

The Consolidated company purchases customs ores from small mines in British Columbia and in the State of Washington, but nearly all of the zinc and fully 90 per cent of the lead and silver are from its own mines, the Sullivan at Kimberly being the principal source.

The program for plant expansion at Trail, some of which is finished and all of which should be completed in 1925, includes: enlargement of the silver refinery and the addition of a plant for working up antimonial residues into merchantable metal; a new drossing and lead anode-casting plant; a new stack that will be higher than any of the existing stacks and that will have sufficient natural draft to avoid the necessity of fans; four new Cottrell fume treaters; one Dwight-Lloyd roaster for the zinc plant and three Dwight-Lloyd sintering furnaces for the lead plant; a new boiler house and several additions to the foundries and machine shops, to enable all kinds of metal work to be done by the company's own employees.

Important additions are under way in the electrolytic lead and zinc refining departments. The lead plant, formerly rated at 178 tons of finished metal per day, ultimately will have a capacity of 300 tons, or more than 200,000,000 lb. of lead per year. The zinc plant capacity will be nearly doubled, so as to handle 190 tons slab zinc daily. Several million dollars will be involved in the complete construction program.



Trail smelter on the Columbia River

Owned by the Consolidated Mining & Smelting Co. of Canada. This is one of the most complete metallurgical establishments in existence.

The Sullivan concentrator has a capacity of 3,000 tons of ore per day. The coarse-crushing department, however, can handle 6,000 tons, and it is possible that the capacity of the remainder of the plant may be increased materially. The concentrator began operation in August, 1923, though shortage of power limited production for many months following.

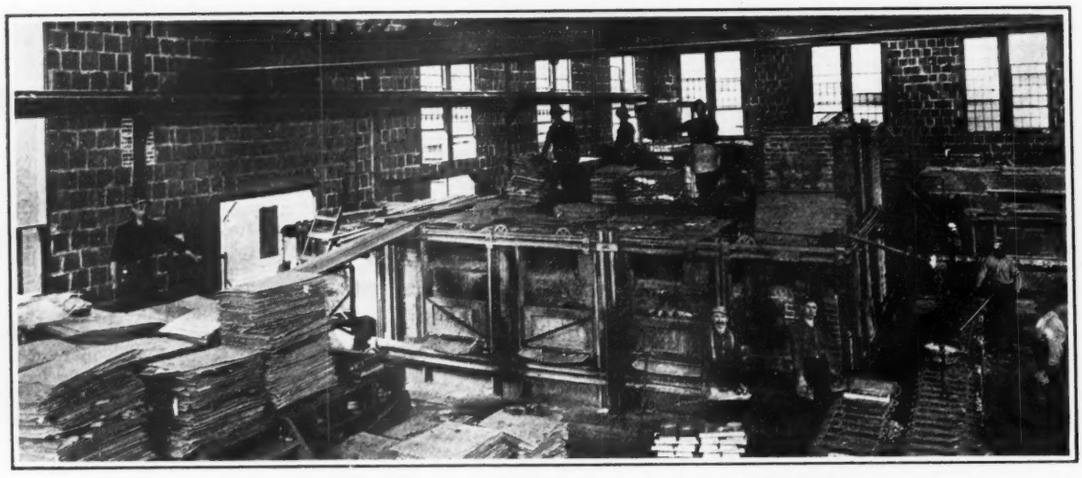
The plant is entirely modern, and was designed after research work on the Sullivan ores dating back to 1910. The treatment of these complex ores is by a selective flotation process by which a high degree of metallurgical efficiency is attained. A process known as the French zinc process was tried in 1912, but no advantage was found by using it, so it was dropped. Recently, however, a patent suit has been brought against the company by the owners of this process.

The West Kootenay Power & Light Co., subsidiary of the Consolidated M. & S. Co., is installing three new 20,000-hp. units in connection with its Bonnington Falls hydro-electric development. Additional power has been made available during the past year, and an adequate supply will be assured by the end of 1925.

The Sullivan orebody is reputed to be "one of the largest known deposits of lead-zinc ore." The country rock consists of a great thickness of Pre-Cambrian clayey quartzites which have been invaded by intrusive sheets of gabbro. The quartzite has been greatly folded and fractured. Post-mineral faults occur, but they do not result in difficult development problems. The ores are massive replacement deposits in quartzite, having the features, however, of a regular vein, consisting of pyrite, pyrrhotite, sphalerite, and galena, usually closely intergrown. The beds are said to be from 200 to 240 ft. thick. The sulphides vary in relative amounts from place to place, and certain parts of the mineralized zone consist predominantly of a single sulphide. The company acquired control of the property in 1910, since which time the mine has been the scene of active development by underground work and diamond drilling. The total mining development exceeds 10 miles, and the shipments of ore to date total more than 2,100,000 tons. The average mill feed of Sullivan ore has been said by the company's engineers to be: lead, 11.0 per cent; zinc 10.5 per cent; and silver 3.0 oz.

The company does not publish any statement of its ore reserves either as to grade or tonnage. In answer to a query on this point from a stockholder at the annual meeting last spring, the president said that "the ore reserves at the Sullivan mine are capable of supplying the mill for the next twenty to twenty-five years." At that time the mill was handling approximately 2,500 tons of ore per day, so that, using the lesser estimate, the indicated tonnage is about 17,500,000. If the grade of the ore reserves is close to the 11:10:3 figure, reputed to be the average mill heads, the deposit certainly stands out as one of the best ever developed.

The Canadian Pacific Railroad Co. recently owned 42 per cent of the 421,348 outstanding shares and 67.4 per cent of $4,000,000 in outstanding bonds. In addition, $2,000 000 of authorized bonds have been hypothecated for a special loan. Earnings of the company after providing for depletion and depreciation and payment for interest on bonds and loans have been as follows: 1921, $338 447.30; 1922, $1,228,329.94; 1923, $2,125,143.34.



Casting slab zinc at the Trail smelter in British Columbia

Current earnings have paid for a large part of the recent plant expansion, including the erection of the Sullivan concentrator and the construction involved in the enlargement of the Trail reduction works. The operations of the company are most capably managed, and the technical direction is of outstanding quality. The one factor in the outlook for the company that might give cause for uncertainty is the extent and assay content of the ore reserve. The shareholders and the public at large would like to see an official statement regarding ore reserves in the forthcoming annual report.

Kennedy Cutting Station and Ore Pocket at 4,350 Ft.

The Kennedy Mining & Milling Co. at Jackson, Calif., has extended its main working shaft from the 4,250 to the 4,350 level, at which point a station and ore pocket are now being cut. The bottom of the vertical shaft is at a depth of 4,462 ft. below the surface, the additional depth of 112 ft. below the 4,350-ft. station level serving as a sump. The shaft is 7x19 ft. outside dimensions and was sunk 150 ft. in sixty days at a contract price of $40 per ft., the company supplying materials and power.

Seventy-five stamps are now dropping, and it is expected that an additional five stamps will be started soon.

Pierson Mines Co. Drives Crosscut Tunnel

The Pierson Mines Co., a closed corporation headed and controlled by R. B. Whiteside, iron-ore mine owner of Duluth, Minn., is developing the Pierson property, 6 miles east of Independence, in Inyo County, Calif. Four semi-Diesel engines of 200 hp., air compressor and drills, electric generator, electric storage-battery locomotive and a mucking machine are included in the equipment. These are being used in the extension of a crosscut tunnel about 3,100 ft. to intersect four known ledges which on the surface have yielded high assays. The tunnel is now in 1,300 ft.

Two Fires in Joplin-Miami District; Loss $75,000

Fire of undetermined origin completely destroyed the Fort Worth mill, situated in the southeast portion of Picher, Okla., in the Joplin-Missouri district, on Jan. 20. The property was owned by the Childress Lead & Zinc Co., composed of Frank and G. L. Childress, of Joplin. The loss is estimated at about $75,000, about half covered by insurance. The mill will be rebuilt, as the property was producing well. The mill had been rebuilt only about three months ago, the mine having been idle several years.

Heavy loss by spread of the fire to other near-by mines was prevented by prompt and efficient work on the part of the officers and men of the Picher fire department.

Mount Lyell Mines Earned Profit Despite Low Copper

Latest reports from the Mount Lyell mines, in Tasmania, Australia, show that work there continues to go on satisfactorily. In the last financial year of the company the working account disclosed a profit of £191,400. The average assay value of the whole of the ore treated in the period (112,278 tons) was 5.9 per cent of copper, 1.05 oz. silver, and 0.018 oz. gold.

Preliminary work is already in progress for making important alterations and improvements at the North Lyell property, and when this is completed use will be made by the company of the shaft of the former Mount Lyell Blocks Co., the property of which was acquired by Mount Lyell some years ago. The directors of the latter company paid a dividend of 1s. a share in December. Considering the low price at which copper has ruled during the last year or two, shareholders are naturally pleased at receiving this distribution. The company, however, has an associated enterprise in its superphosphates business, which yields good profits, though the field is not so clear as when co-operative concerns had not yet entered actively into this class of manufacture.

Ship 40 Per Cent Lead from Old Chloride District

Once again after another periodic abandonment, the historic and romantic old Chloride camp, in the Black Range, in New Mexico, is resounding to the ring of single-jack on seven-eighths "hex." L. E. Foster, formerly chief engineer of the Chino Copper Co., and E. Perrault and other associates have taken over the old Bald Eagle mine and other properties on the Pye vein, and after only a month of operations, the first carload of 40 per cent lead sulphide is being hauled to Engle, the nearest railway point, 60 miles southeast. Drifting is progressing rapidly along the orebody, which shows 1 ft. of 40 per cent lead ore.

The history of the old Chloride camp is as interesting and romantic as any in the state. Once Colonel Bob Ingersoll came into the camp and planked down $60,000 in gold, with scarcely any formality or contract, and purchased outright the Ivanhoe claim. Immediately thereafter, he shipped his one and only car of ore, which netted well over $100,000—and quit while the quitting was good.

Red Hill-Florence Leases Ground at Tonopah

The Red Hill-Florence Mining Co., formerly operating in the Goldfield district, in Nevada, has acquired a lease and bond on the Molly group of claims, at Tonopah, Nev., and a lease on a part of the property of the Buckeye-Belmont Mining Co., and has arranged with the last named company to operate through its shaft.

This ground lies to the south and east of the Rescue Eula and the Halifax properties, and recent development work in this vicinity has proved the existence of trachyte in this area. Trachyte is the most important of the several ore-bearing formations in the Tonopah district, and it is in this rock that the richest veins have been found.

J. E. Bevis, of Reno, Nev., who was directly responsible for the success of the negotiations, will act as general superintendent.

Empire Zinc Co. Leases Hedley Holdings in New Mexico

The Empire Zinc Co., a subsidiary of the New Jersey Zinc Co., recently has taken a lease and bond on the entire holdings of the Hedley Gold Mining Co. at Copper Flat, 2 miles southwest from its zinc mines at Hanover, N. M.

Already shipments of zinc carbonate ore have been made from shallow surface workings, and at the same time work is going forward in the installation of new hoisting and pumping machinery on one of the deep shafts on the southwestern part of the property.

The lease and bond covers twelve patented claims, including the Little Key, Congo, Free Silver, Silver Key and Cumberland mines, and lies in the highest eminence of the plateau country looking into the Chino copper pits. This property has always been considered a copper mine, and that the zinc company has taken it over has caused some surprise.

Years ago, the Hedley Gold Mining Co. spent several hundred thousand dollars in diamond drilling and sinking exploratory shafts and establishing a steam surface plant with compressors; but the owners did not put the property on a producing basis.

Davis-Daly Settles Dispute with East Butte

The controversy, involving a broken smelter contract, between the East Butte Copper Mining Co. and the Davis-Daly Copper Co. has been settled out of court on a mutually satisfactory basis. The attachment on Davis-Daly funds will be removed.

Arrangements have been made whereby the Anaconda Copper company will treat the East Butte ore at a rate lower than the East Butte can treat it at its own smelter.

In view of the advantageous smelting contract and a 15c. copper market, the East Butte management feels justified in resuming operations. Preparations are being made to that end.

A. S. & R. May Increase Earnings

The American Smelting & Refining Co., officials estimate, will show earnings in the first quarter of 1925 at the rate of around $14 a share a year upon the 609,980 shares of common stock after preferred dividends and all charges. Earnings for 1924 were between $12 and $13 a share. United States and Mexican plants of the company are operating efficiently, and earnings from Peruvian operations are increasing.

Rich Strike in Republic Mine

Rich gold-silver-lead ore has just been opened at the Republic mine, 7 miles north of Caliente, Nev. Ore is now being sacked for shipment. Only a small amount of development work has been done to date, the present shaft being sunk to a depth of 50 ft. with ore showing all the way down. L. L. Burt and J. W. Matthews are operating the property themselves.

News from Washington

By PAUL WOOTON
Special Correspondent

Philip S. Smith and Party Mapped 20,000 Square Miles in Alaska

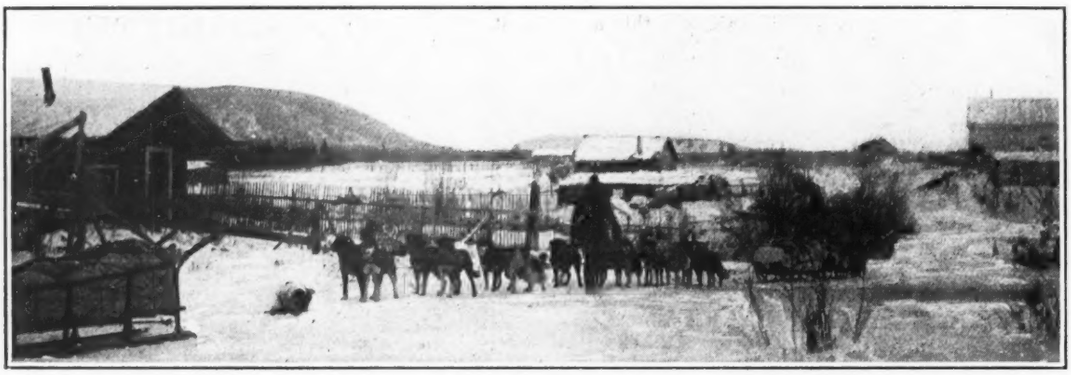
Efficient Planning Facilitated Exploration Above Arctic Circle—Good Indications of Oil Are Found—Transportation Problem Difficult

THOUGH some newspaper space has been given to the exploit of P. S. Smith, of the U. S. Geological Survey, and the geologists and topographers associated with him last season in the mapping of more than 20,000 square miles above the Arctic Circle in northwestern Alaska, that publicity has given no adequate indication of the really remarkable character of this feat. The very efficiency of these men robbed their notable adventure of spectacular features. They knew the North. They knew how to prepare. They overlooked nothing. The expedition was planned thoroughly in advance. Consequently, nothing went wrong. There was no shortage of food. No one was lost in the wilds where for six months they encounted no human being.

Philip S. Smith

Had these men been inefficient in their planning and careless in their calculations they easily could have had harrowing experiences. Some of the men might have been lost. Others might have sacrificed limbs to the frost. The survivors might have staggered into Point Barrow just as hope for them was being abandoned. Instead, everything came out precisely as had been planned. All members of the expedition reached the seaboard at the end of the season without untoward incidents or for a moment being uncertain of their whereabouts. These facts, combined with the modesty of the men, have robbed a great achievement of much of the popular attention which might have come from such an effort. Ply these scientists with questions as you will, none admits having undergone any hardship. Those who know Alaska take these assertions with some reservations. The temperatures are known. It also is known that much of the work on surveys of this character must be done from exposed points. Even the pictures the men themselves took, show them wading in ice water. It unquestionably is true that they faced no serious situations, but to plunge into the midst of any unsettled, unknown region where no outside assistance or supplies can be obtained, with only such equipment as could be carried on dog sleds and canoes, requires abundant courage. The darkness, the absence of trails, the cold, the lack of shelter, the bitter winds, and the snow, the absence of information regarding even the larger aspects of the region, constitute a few of the obstacles that can be appreciated without an actual knowledge of Alaskan conditions.

Near headquarters camp on tributary of Colville River, where Survey parties awaited the spring "break-up"

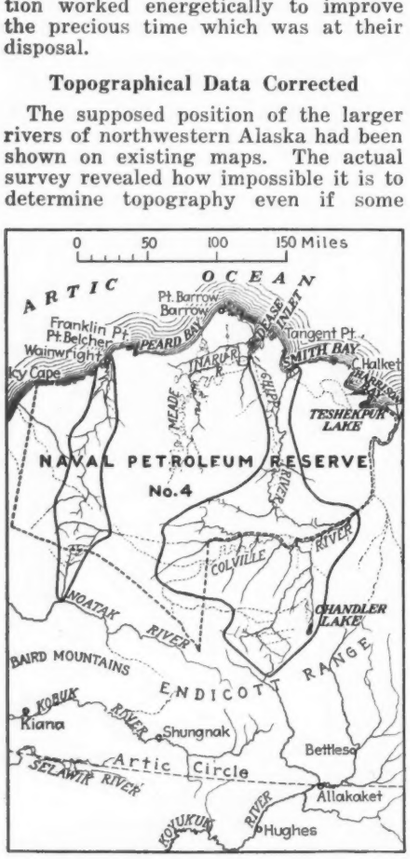


Geological Survey dog teams leaving Tanana, Alaska, for Naval Petroleum Reserve No. 4

The men went out into the long polar night so that they could be on the Arctic slope, where they were to work, at the earliest possible moment, so as to utilize fully the summer season, when geologic investigations could best be made. Each member of the expedition worked energetically to improve the precious time which was at their disposal.

Topographical Data Corrected

The supposed position of the larger rivers of northwestern Alaska had been shown on existing maps. The actual survey revealed how impossible it is to determine topography even if some facts are known. Though it apparently had been a safe assumption that the drainage from the Brooks range—so named as a memorial to the late A. H. Brooks, who took such an important part in working out the geology of Alaska—was in general northward, it was found that some of the streams flowed east instead of west.



Above the Arctic Circle

The dark lines show the area explored by the Smith party.

A broad plain separates the shore line of the Arctic Ocean and the mountains. It is here that seepages indicate the presence of petroleum. The surface of this coastal plain is made up of gravel, sand, and mud. The indications are that these unconsolidated materials overlie rocks similar to those which come to the surface further south, but there has been no opportunity as yet to learn how extensive the oil sands may be. The rocks are of a coal-bearing series, rather than of the types usually found in oil-producing regions, but the structure is favorable to the accumulation of oil and gas. It is probable that more detailed surveys of favorable localities will be recommended and that the logical step to take next will be the testing of the seepage area by drilling. No particular difficulty would face the sinking of test wells, and the obvious course would be for the Navy to finance such an undertaking. If oil should be found in quantity there is no thought of attempting to utilize it now. It would be held in reserve until such time as it would be feasible to undertake production under the great difficulties which necessarily would be encountered.

Pipe-line Cost Would Be Enormous

Since the open season for water transportation on the Arctic does not exceed one and one-half months, a pipe line 900 miles long to a harbor free of ice throughout the year or even a railroad might be required to get out the oil. This would necessitate an undertaking as expensive and as difficult as the construction of the existing Alaska Railroad. The cost of operating such a pipe line, which would have to be heated throughout its length, would be enormous. Any development of the field, even should the presence of oil in quantity be established, undoubtedly would be a matter of military need rather than of practical commercial feasibility.

The coal resources of the Arctic slope are extensive. Much of the coal is of high quality, but extensive use of this fuel is unlikely, owing to the difficulty of getting it to any market without unreasonable expense.

Dr. Smith and his associates, in addition to the information concerning the geology and the topography of northwestern Alaska, brought back detailed information as to its flora and fauna and precise observations of a meteorological character.

House Committee Approves Bill to Buy 14,500,000 Oz. Silver

Believes Pittman Act Should Then Be Repealed to Avoid Possibility of Its Abuse

"The Pittman Act having been passed in good faith, your committee deems it unwise to breach that faith by a refusal to carry it out or to allow the Comptroller General of the United States to set aside a solemn act of Congress because in his judgment it is expedient to do so." Thus without gloves the Banking and Currency Committee of the House of Representatives reports its findings in connection with the proposal to purchase 14,500,000 more ounces of silver at $1 per ounce. The bill already has passed the Senate.

After quoting the two mandatory provisions of the Pittman Act, the committee in its report says:

"Under the two mandatory provisions over 200,000,000 dollars were melted up and were sold to Great Britain and an equal amount of silver purchased as provided by law. There also were allocated to the Director of the Mint 14,589,730.13 ounces of fine silver for coinage. No repurchase to cover this allocation (or sale) ever has been made. Under the law this allocation was a sale and the Treasury was bound to repurchase under the terms of the Pittman Act a like amount of silver. This they did not do. Inasmuch as the Pittman Act was mandatory as regards the repurchase of silver sold, there was no discretionary power lodged with the Treasury in this instance."

The committee amended the Senate bill so as to restrict purchases at Pittman prices to the amount mentioned in the bill now before Congress. It is necessary to repeal the Pittman Act, the committee says, "because there still could be allocated to the Mint and broken up for subsidary coinage approximately 130,000,000 oz. of silver and upon such allocation the Treasury could proceed to purchase approximately 130,000,000 oz. at $1 per ounce, which would be above the market price. As the purpose of the act will have been completed when the present contemplated purchase is made, it is unwise to leave the act open for an opportunity for abuse hereafter in manipulating the silver market."

London Letter

By W. A. Doman
Special Correspondent

San Francisco Mines Report Shows Some Improvement

Metallurgical Results Are Better—May Grind Fine for Flotation—Rhodesia Prosperous

London Jan. 27—Though the annual report of the San Francisco Mines of Mexico shows an immense improvement over its predecessor, a slight feeling of disappointment was engendered because of the water trouble and the resignation of Whitaker and Schlereth, the consulting engineers. At the beginning of the period, Oct. 1, 1923, the inflow was approximately 350 gal. per minute, and at the end of the year 1,250 gal. Emergency pumps were installed and others ordered. The water made its entry from transverse fissures, and hindered development in the south end of the mine on No. 6 level, the face of which drive is in good ore. To the north of the shaft on levels 5 and 6 developments have been most gratifying, and as a result the company has acquired, through a local undertaking, the adjoining Nigromante property, which now protects the vein along its northern extension. Level No. 4 south has been particularly successful, having proved the extension of the ore-bearing vein for more than 100 m. beyond the point previously thought to be the termination. To secure any further extension, the Cuadras claims also have been acquired by the local company. The pumping problem has prevented a two-years' sulphide ore reserve at the rated mill capacity of 500 tons daily. The ore reserves are stated as 210,448 tons of sulphide, 102,103 tons of oxidized, 108,194 tons of zinc residues, as well as 82,402 tons of partly blocked sulphide ore and 41,406 tons of partly blocked oxidized ore.

Metallurgical improvements have increased the lead and decreased the zinc content in the lead concentrate, as well as the lower metal values in the final tailing. Finer grinding previous to flotation is indicated as advisable, and the matter is under consideration.

It is reported that in a crosscut to the north the Globe & Phœnix Co. (Rhodesia) has cut a rich lode. As the crosscut is of some length, the question has to be determined, it is said, whether the find is in the Rhodesia Exploration ground. If the Globe & Phœnix is following its extralateral rights there will be no difficulty, but it is not yet settled whether this is a new reef.

J. G. McDonald, consulting engineer to the Gold Fields Rhodesian Co., says that the prospects for mining in Rhodesia never looked better. He bases his opinion upon the excellent developments in the Cam & Motor, the Rezende, the Sherwood Star, the Lonely Reef, and even the Shamva. The Falcon Mines, a copper property, has fallen upon bad times, and the government is being approached for financial assistance.

Some time ago I mentioned a rumor of a reported discovery of a silver-lead property in Burma. Information concerning this area is not easy to obtain, but from what I can gather there are numerous old workings covering many thousands of acres. The property is being examined by one of the leading geologists, and it is quite likely that more will be heard of it in the not distant future.

Leaders of the tin-mining industry in Cornwall have become quite optimistic, particularly in consequence of a stable government in this country. Captain Moreing, M. P. for the Camborne division, states that there is mineral in Cornwall in almost untold quantities; in fact, he describes it as one of the richest mineralized zones to be found in the world, and he maintains that there is more tin in the Duchy than has ever been dug out of it.

C. & H. Cuts Down Copper Stock by 8,525,000 Lb.

Calumet & Hecla Consolidated's copper on hand was reduced 8,525,000 lb. during the final quarter of 1924. Metal unsold on Dec. 31 was approximately 39,375,226 lb., compared with 47,900,000 lb. on hand Oct. 1. This is deduced from the company's quarterly financial statement recently issued. Its supply of copper Dec. 31 was valued at $5,866,-908.75, and the price per pound Dec. 31 was 14.90c. On Oct. 1, copper on hand was valued at $6,101,438.45 and the price was 12.875c. per pound.

High-grading Bill Introduced in California Legislature

Assembly bill No. 333, providing a licensing system for all ore and bullion buyers in California, has been introduced into the California Legislature. The bill follows closely the Colorado statute, a law which has been successful in controlling ore and bullion stealing. The bill in question has been referred to the Assembly Committee on Mines and Mining. Mining interests especially desire the bill to pass, as it is estimated that about $481,000 worth of gold bullion was stolen in 1924. It is hoped that the passage of this bill will materially reduce the annual loss now suffered by gold producers.

Radium Mining in Australia

A company has recently been formed in Adelaide, South Australia, with a capital of £100,000, to take over from the Radium & Rare Earths Treatment Co., three radium mining leases, and an option agreement has been entered into with the Mount Painter syndicate over fifteen other mineral leases in South Australia. On two of the claims acquired hand-picked ore is to be raised immediately and other development work is to be carried out. The Radium & Rare Earths Co. is erecting the first unit of a plant at Adelaide to treat three tons a week of the new company's ore. It is stated that the process for treatment is comparatively simple. Sir Douglas Mawson has been visiting the field to report on it.

Toronto Letter

By Our Special Correspondent for Northern Ontario

New Oreshoot in La Rose Mine Looks Big

Mond Nickel Co. Will Build Acid Plant —Railroad to Rouyn Seems Assured

Toronto, Feb. 8—Further work on the new oreshoot discovered at the Violet mine on the La Rose company, in Cobalt, indicates the most important discovery by this company for several years. Only a comparatively small amount of work has as yet been done, but the vein shows from 3 to 6 in. of 3,000- to 4,000-oz. ore, in addition to about 5 ft. of high-grade mill rock, estimated to run about 50 oz. to the ton. The oreshoot was found at a depth of 830 ft. and the company has started sinking again to get under it.

The Mining Corporation has issued a quarterly progress report which shows that for the three months ended Dec. 31 the production from Cobalt and South Lorrain amounted to 381,000 oz. silver. Substantial output is still being maintained from the Cobalt properties, and the new vein in South Lorrain is exceeding expectations. A 36 ft. raise produced thirty tons of 3,000-oz. ore and the top of the raise shows 10 to 18 in. of high grade. The No. 3 shaft on the South Lorrain properties has been completed to the 675 ft. level, and it will now be possible to carry on a vigorous development campaign on the seventh and eighth levels. On the Lorrain Trout Lake property, which the Mining Corporation manages and in which it has a substantial interest, 775 ft. of underground work was done.

The Mond Nickel Co., of Sudbury, will erect a contact sulphuric acid plant in connection with its smelter at Coniston. Actual construction work will start as early as possible in the spring, and it is hoped that acid will be produced before the end of 1925. The plant is expected to have a capacity of 25,000 tons a year and will be the first of its kind to be used in nickel mining. Much sulphur dioxide gas has been going to waste in the Sudbury district.

Sir Henry Thornton, president of the Canadian National Railways, has announced that permission will be asked at the present session of Parliament to construct a branch line from Micmac into the Rouyn gold district. Quebec interests have been anxious to secure a line into this country that would enable Quebec business men to compete with those of Ontario for the large amount of business which will result through the development and opening up of this country. It is believed that with the definite assurance of railway facilities, the Noranda Mines, Ltd., controlling the Horne copper-gold deposit, will make arrangements for the equipment of properties and the construction of a smelter. The distance from Micmac to Rouyn is approximately 35 miles. It is also quite probable that the Ontario Government will extend the Kirkland Lake branch in to meet the C. N. R. line.

Societies, Addresses, and Reports

Engineers' Licensing Bill, in California, Opposed by San Francisco Section of A.I.M.E.

At a recent meeting of the San Francisco Section of the American Institute of Mining and Metallurgical Engineers a committee was appointed to report upon the engineers' licensing bill which was introduced in the California Legislature as Assembly Bill No. 333. The report of the committee, of which Wilbur H. Grant was chairman, is as follows:

"The San Francisco Section of the American Institute of Mining and Metallurgical Engineers, in meeting Jan. 13, 1925, emphatically and unanimously opposed any attempt to license professional engineers in California.

"Licensing would add another direct tax to the heavy and ever increasing tax burdens that we already bear and this without benefit of any kind to the public or to the best elements of the profession.

"The definition of 'engineer' is loose and endless confusion and injustice would surely result from any attempt at licensing. The undesirable element cannot be eliminated by such means. The public is now amply protected by laws in force governing those branches of 'engineering' that involve the handling of life and property, in building inspection laws, and other similar statutes.

"The proposed law would permit any licensed engineer to perform any kind of engineering work, regardless of his qualifications. This completely vitiates any protection to the public. For example, a man competent in chemical engineering would have the right to design and erect a Golden Gate bridge and in so doing endanger the lives of thousands.

"The Federal Government already has a system for selecting technically trained men for public employment and this should be the system adopted for states and municipalities, to the total exclusion of any licensing system.

"The progress of California has been largely due to freedom from governmental restrictions and the encouragement of creative individualism. We strongly recommend that this old and effective policy be preserved for engineers.

"No college degree nor term of work nor license by any authority makes the engineer competent. The ability to use the laws of Nature, to make use of the knowledge of other men and the possession of good sense and integrity are the principal elements in the value of an engineer. These cannot be standardized.

"Because of the difficulty of defining the profession of 'engineer,' it would be equally difficult to secure a commission to pass on the applications. The best men of the profession would be required and these would not serve; the best men never do serve in such positions.

"Licensing laws in the several states that have them were not demanded by the public, by the leading, successful, engineers, nor by the national societies of the several engineering professions. They were pushed through by a well-organized minority of men holding subordinate positions in the hope of obtaining an increase in pay. The real reason behind the movement is the desire of young engineers and older men who have not progressed to get a standing to which they are not entitled. Licensing helps only the incompetent and lowers the standard. It puts the tyro on the same plane before the public with a Hoover or a Freeman.

"The existing laws for the licensing of engineers have been largely vitiated by 'jokers' and amendments, and there is a distinct reversion of public opinion against this phase of legislation. Qualifications are usually rigid enough on their face to deceive the legislators but loose enough to admit the class that has invariably sponsored the movement.

"Judge Samuel E. Schull, Court of Quarter Sessions, Monroe County, Pennsylvania, on July 2, 1923, declared the Pennsylvania law for the licensing of engineers unconstitutional and is quoted as having said: 'A careful study of the act shows that its intention was not alone the safeguarding of life, health and property, but is another eruption of the present day itch to regulate everybody and everything by law.' We concur in this and strenuously oppose this tendency.

"If the abuse of the practice of engineering as a whole ever becomes formidable, the mining engineers will favor most rigid corrective measures, but they can see no reason for such action now in the United States."

South African Geologists Discuss Local Phenomena

At the December, 1924, meeting of the members of the Geological Society of South Africa three technical papers were presented and read. A. L. Hall discussed "Metallic Sulphide in Asbestos from Kaapsche Hoop," Dr. P. A. Wagner "The Geology of the Areas Situated East of the Confluence of the Oliphants and Elands Rivers in Central Transvaal," and Dr. W. A. Rogers, "An Occurrence of Diapose."

Institute of Metals Meeting Set for March

The annual general meeting of the Institute of Metals will be held at the Institution of Mechanical Engineers in London on March 11 and 12. Twelve communications are to be presented at the meeting. The annual dinner will take place at the Trocadero restaurant on March 11.

The thirty-second volume of the *Journal* of the Institute of Metals, a book of 832 pages, has just been issued.

Wilbur Nelson Elected Head of State Geologists

At the annual meeting of the Association of American State Geologists held in Ithaca, N. Y., Dec. 29 to 31, the following officers were elected for 1925: President, Wilbur A. Nelson, State Geologist of Tennessee; secretary, M. M. Leighton, State Geologist of Illinois; Member of Executive Committee, E. W. Matthews, State Geologist of Maryland.

The association voted to send a memorial to the President of the United States requesting a liberal support to scientific work. The memorial was presented in person by the new president of the association and was favorably received.

Princeton's Mining Course

Princeton was not included in the list of mining and allied educational institutions that was published in 56th Annual Review of the *Mining Journal-Press* that appeared on Jan. 17 last. According to Arthur M. Greene, Jr., dean of the School of Engineering at Princeton, however, the school has a department of mining engineering, although the degree of mining engineer is not being given. The function of this department, he states, is to prepare students so that they may take the degree of mining engineer at some high-grade mining school after two years' additional work. The department of geology of Princeton University, which gives the principal mining work in this course, has graduate courses leading to the degree of Ph.D.

Idaho Mining Association Will Meet at Boise

The eleventh annual meeting of the Idaho Mining Association will be held at the Chamber of Commerce, Boise, Idaho, on Feb. 13 and 14. According to the tentative program addresses of welcome will be delivered by Governor Moore of Idaho, and by Eugene Sherman, Mayor of Boise. Response will be made by C. W. Newton, president of the association.

Haultain Elected President of Professional Engineers

At the annual meeting of the Association of Professional Engineers held in Toronto, Ont., reports presented indicated that substantial progress had been made since its foundation in 1922. A resolution was adopted instructing the council to take steps to have the term "engineer," when used in the professional sense in acts of the legislature, defined as meaning a "registered professional engineer."

The election of officers resulted as follows: President, H. E. T. Haultain; vice-president, H. J. Lamb; registrar and secretary-treasurer, R. B. Wolsey. Members of the council were elected representing the different branches of the profession, those representing the mining engineers being J. Mackintosh Bell, D. E. Keeley, and George R. Mickle.

Men You Should Know About

John K. MacGowan, of New York, and **E. A. Cappelen Smith,** of Sands Point, L. I., have been admitted to partenership in the firm of Guggenheim Brothers. The firm until the admission of the new members was made up of the four Guggenheim brothers, Daniel, Murry, S. R., and Simon. Mr. MacGowan and Mr. Smith have been affiliated with the firm for a number of years and have also represented the Guggenheims on the board of directors of the various corporations owned or controlled by Guggenheim Brothers. Mr. MacGowan started with the organization in 1899; Mr. Smith entered in 1907.

E. A. Cappelen Smith

Lucius W. Mayer, of Rogers, Mayer & Ball, mining engineers, has returned from London.

Charles Janin, mining engineer of San Francisco, left recently for New York and Washington. He will attend the annual meeting of the Institute.

J. Mackintosh Bell, managing director of the Keeley mine, of South Lorrain, Ont., is sailing for England to confer with **F. H. Hamilton,** president of the company.

W. F. Hartman, superintendent of the Mohawk mine, in the Michigan copper country, has tendered his resignation, effective at once. His successor has not yet been named.

H. S. Denny, consulting engineer, of London, left England for Canada on Jan. 24. He will spend about two months in the Dominion, returning to England, probably, in April.

H. D. Budelman, mine superintendent for the West End Consolidated Mining Co., left Tonopah on Feb 1 with Mrs. Budelman for a two months' sojourn in the Hawaiian Islands.

F. Y. Robertson, vice-president and sales manager of the U. S. Smelting, Refining & Mining Co., left on Feb. 6 for a two weeks' trip to Florida. Asked if he was going on business, Mr. Robertson replied "Absolutely!"

J. L. Bray, assistant professor of chemical engineering at Purdue University, Lafayette, Ind., has been appointed a captain in the Chemical Warfare Section, Officers Reserve Corps., U. S. A.

A. A. Hanks, of San Francisco, will represent the San Francisco Section at the February meeting of the American Institute of Mining and Metallurgical Engineers. Accompanied by Mrs. Hanks, he will return to San Francisco via Panama.

T. A. Rickard, contributing editor of *Mining Journal-Press,* will attend a meeting of the Canadian Mining Institute at Vancouver, B. C., Feb. 18, 1925, and en route he will stop at Seattle and deliver an address before the Seattle Section of the Institute.

J. C. Dick, president of the Mountain View and Yankee Consolidated Mining companies, accompanied by Mrs. Dick, has left Salt Lake City for New York and Washington on a combined business and pleasure trip. While in the East Mr. and Mrs. Dick will visit their son, who is attending Dartmouth College. The return to Salt Lake will be made by way of the Panama Canal.

Obituary

Thomas Nixon, a well-known prospector of Emerson, Man., died on Jan. 25 at Drayton, N. D., at the age of seventy-four. He was one of the Yukon pioneers in 1897 and afterward was engaged in prospecting in Siberia and Alaska.

Archie Crawford, secretary of the South African Industrial Federation, died on Dec. 22, 1924, at the age of forty. He had three times represented South African labor at the Geneva Conference and was a delegate to the International Conference at Washington.

Colonel Malcolm Hart Crump, consulting geologist, and one of the best-known men in scientific circles in Kentucky and adjoining states, died in Bowling Green, Ky., on Jan. 14 last, at the age of seventy-five. He was graduated from the Virginia Military Institute with distinction in the class of 1873. For a number of years, Colonel Crump held the chair in the department of science at Ogden College. Later he maintained an office as consulting geologist in Bowling Green, and was among the first to recognize the great possibilities of Kentucky rock asphalt and to assist in its development. Colonel Crump was a member of Royal Society of Arts, the Kentucky Academy of Science, and other scientific societies. In 1880, he assisted in organizing Bowling Green Guards and was captain of that organization for a number of years. He served as major in the Spanish-American War and retired as lieutenant colonel.

Dr. Willet Green Miller, Provincial Geologist of Ontario, died suddenly at Toronto on Jan. 4 from meningitis. Dr. Miller was fifty-eight years old. For many years he had been prominently identified with the mining industry of Ontario, on which he was a recognized authority of wide reputation. Dr. Miller was born in Norfolk, County, Ontario, both of his parents being Canadians, and was graduated with honors at the University of Toronto in 1890. He took post-graduate work in Chicago, Harvard and Heidelberg universities, receiving from the latter the honorary degree of LL.D. For nine years he was on the staff of Queen's University, Kingston, Ont., and in 1902 became Provincial Geologist. Following discoveries in the Cobalt area he was appointed to make an investigation, and his report was the first to announce it as a silver field, it having previously been regarded as a copper area. The work of Dr. Miller has been a most important factor in the development of the Ontario mining industry. His high professional standing gave him the confidence of investors in the United States and Britain, resulting in a large influx of capital from abroad for the promotion of mining enterprises. In recognition of the esteem in which he was held in financial circles, the Provincial Government sent him to England last year in connection with the mission undertaken by the Department of Mines to bring the opportunities offered by the mines of north Ontario to the attention of British investors. Last year he received the honor of being chosen president of the Geologists Section of the British Association for the Advancement of Science. During the war period Dr. Miller rendered important service as Canadian representative in the Imperial Resources Bureau in London and as a member of the commission which reported on the Ontario nickel industry, refusing to accept the honorarium offered in connection with the latter position. He was unselfish in his devotion to the public service, and although frequently offered positions with private corporations at four or five times his official salary, invariably declined to avail himself of these opportunities for personal advancement. Dr. Miller was unmarried. He was an ex-president of the Canadian Institute of Mining and Metallurgy, a Fellow of the Royal Society of Canada, a member of the A.I.M.E. and of the Engineers Club.

Willet G. Miller

Recent Technical Publications

Reviews, Abstracts and References

A Revision of Hofman's "Metallurgy of Copper"

Metallurgy of Copper. By H. O. Hofman. Second edition, revised by Carle R. Hayward. McGraw-Hill Book Co., New York. Price $5.

Hofman's book on copper was first published ten years ago, being part of a series of books on general metallurgy, copper, lead, and zinc and cadmium. Since it was first published, it has shared pre-eminence in its field with the two books of Professor Peters, "Principles of Copper Smelting" and "Practice of Copper Smelting." Peters was especially good in setting forth the metallurgical fundamentals and in discussing methods of operation, whereas Hofman covered more at length the equipment used and gave much data on tonnages, analyses, and similar statistical information from various plants. The illness and subsequent death of Professor Hofman has made it necessary to call in another to revise his book for the second edition, and Carle R. Hayward, who is associate professor of metallurgy at the Massachusetts Institute of Technology, has proved to be an excellent choice for the work.

The first 66 pages, covering the properties of copper, its grades, impurities, alloys, compounds, and ores, are not greatly different from the first edition. The page make-up has been entirely changed, but none of the numerous footnotes appear to refer to any of the literature later than 1913. The analyses given of Utah and Nevada copper ores are considerably out of date.

The extensive chapter on smelting, comprising over 200 pages, has been more thoroughly rewritten; a wealth of recent data are given on furnace operation, and the latest equipment is described. We are inclined to doubt whether the blast-furnace smelting of sulphide ore can be divided into three processes, the roasting and reduction process, the pyritic process without carbonaceous fuel, and the partial pyritic process. We have never known a copper blast furnace to operate without carbonaceous fuel; certainly it is not now being done on this continent, though it may have been done on rich ores before our time. The section on roasting furnaces is excellent. That on blast furnaces has not been changed so materially, because not much has been done about blast furnaces since the first edition was printed except to cease using them. It might have been well to talk about the Grand Forks and Greenwood, B. C., furnaces in the past tense instead of the present, and the photograph of "Blast furnaces, Shannon Copper Co." on page 111 leaves something to be desired. The sections on reverberatory smelting and converting are thoroughly revised and truly representative of present American practice.

The last chapters of the book, of 120 pages, cover leaching, electrolytic precipitation, and cost data. Space did not permit extended discussion of these subjects, but that which is offered is well selected.

All in all, this is an excellent review of the tools of the present-day copper metallurgist and what he has done with them in the United States and neighboring countries. Foreign critics may complain that processes and equipment used in Europe, Africa, and Australia have been neglected, but no one copper metallurgist can speak with authority on what is going on throughout the world, and rather than publish a lot of second-hand and out-of-date data about foreign plants, we think the authors have used excellent judgment in limiting the scope of the book as they have.

E. H. ROBIE.

Electrical Prospecting — Electrical prospecting by the Lindblad-Sundberg-Vos methods is described in a 4-page article in *The Mining Magazine* for December. (London; price 1s.)

Mining Costs—In the October issue of the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa (Johannesburg; price 3s. 6d.) is a practical article of 15 pages by Erroll Hay describing "A Method of Controlling Working Expenditure on the Mines."

Mine Fires—Also, in the magazine mentioned just above, is a 10-page article by J. M. Templeton on "The Underground Fire at the Government Gold Mining Areas, Southeast Section," illustrated with charts and diagrams.

Canadian Antimony Ore—"The Lake George Antimony Ores and Their Concentration" is the title of a 6-page mimeographed bulletin by C. S. Parsons, recently published for free distribution by the Mines Branch, Department of Mines, Ottawa, Canada.

Electric Mine Hoists—The August issue of *Compressed Air Magazine* (New York; 35c. per copy) contains a four-page article by H. V. Haight describing two new air-controlled electric mine hoists recently purchased by the Coniagas and the Porcupine Davidson mining companies, in Ontario.

Explosives—Technical Paper 358 of the U. S. Bureau of Mines, Washington, D. C., 32 pages, obtainable on request, covers the production of explosives in the United States during 1923, with notes on mine accidents due to explosives. William W. Adams is the author.

Montana Oil—"Geology and Possible Oil and Gas Resources of the Faulted Area South of the Bearpaw Mountains, Montana," is the title of Bulletin 751-C of the U. S. Geological Survey, Washington, D. C., 44 pages, obtainable on request. It is by Frank Reeves.

Feldspar—"Feldspar, a Mineral Having Many Uses" is the title of a four-page article in *Compressed Air Magazine* for September (New York; price 35c.), by A. S. Taylor. The mine and mill of the Crown Point Spar Co., in northern New York, are described.

South African Nickel—The Geological Survey of South Africa has published Memoir No. 21, 181 pages, on "Magmatic Nickel Deposits of the Bushveld Complex, Rustenburg District, Transvaal," by Percy A. Wagner. The deposits have not yet been proved of commercial importance, but geologically are admirable examples of magmatic sulphide segregations, with the evidence of syngenetic origin particularly strong. Copies of the bulletin may be obtained for 7s. 6d. from the Secretary for Mines and Industries, Pretoria, South Africa.

Mineral Resources — Recent separates of the "Mineral Resources of the United States, 1923," obtainable free from the U. S. Geological Survey, Washington, D. C., include: "Copper," 48 pages, by Helena M. Meyer; "Antimony," 16 pages, by Frank C. Schrader; "Iron Ore, Pig Iron and Steel," 34 pages, by Ernest F. Burchard and Hubert W. Davis; "Phosphate Rock," 34 pages, by George Rogers Mansfield; "Lime," 10 pages, by G. F. Loughlin and A. T. Coons; "Feldspar," 7 pages, by Jefferson Middleton; and "Cement," 32 pages, by E. F. Burchard and B. W. Bagley.

Western Australian Mining—The Department of Mines of Western Australia has issued a 267-page report for 1923. Statistics of the mining industry in that province are given, together with descriptive papers covering some of the mining districts. Copies may be had from the Department at Perth.

English Iron Ore—The hematites of West Cumberland, Lancashire, and the Lake District are discussed by Bernard Smith in Vol. 8, Memoirs of the Geological Survey, 236 pages. This is the second edition of this work. It is obtainable for 5s. net, from H. M. Stationery Office, Adastral House, Kingsway, London, W. C. 2, England.

South African Power Plants — The August issue of *The South African Power Engineer*, Johannesburg, contains descriptive articles of the Randfontein power station, of 20,000 kw. capacity, the largest single mine power station in South Africa; of the Rosherville station, the Rand's largest central power station; and the Kleinfontein central power station.

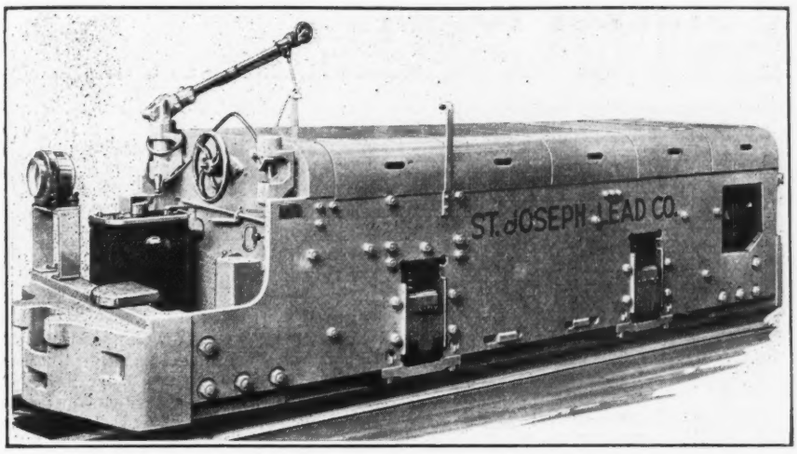
Idaho Molybdenite—U. S. Geological Survey, Washington, D. C., has published for free distribution Bulletin 750-F, "Molybdenite in the Rocky Bar District, Idaho," by Frank C. Schrader, covering the geology of the deposits.

Foreign Commerce—Those engaged in foreign trade will be interested in a "Foreign Commerce Handbook" for 1924-1925, published for free distribution by the Chamber of Commerce of the United States, Washington, D. C.

Bituminous Sands — "Bituminous Sands of Northern Alberta" are discussed by Sidney C. Ells in Bulletin No. 625 of the Mines Branch, Department of Mines, Ottawa, Ont., 35 pages, price 25c.

Bureau of Mines—The annual report of the Director of the Bureau of Mines, for the year ended June 30, 1924, 57 pages, is now available from the Superintendent of Documents, Washington, D. C., for 10c.

New Machinery and Inventions



This trolley locomotive is designed for speed and for heavy duty on a 24-in.-gage track

Powerful Trolley Locomotives for Narrow-gage Tracks

The St. Joseph Lead Co., at Bonne Terre, Mo., is operating a fleet of unusual trolley locomotives. The track gage is only 24 in., yet the haul is long and heavy. It was necessary that a trolley locomotive be designed that had speed and could pull heavy loads even on narrow gage.

The locomotives in operation there were built for the 24-in. gage by the Goodman Manufacturing Co., of Chicago, Ill. They weigh thirteen tons and are equipped with two 90-hp. motors, so that they easily pull the heavy loads and are capable of speeds of 15 to 20 miles per hour.

The patented transverse equalizer is said to be a large factor in making it possible for this heavy locomotive of only 24-in. gage to run at such speeds.

The over-motored equipment on the 24-in. gage is made possible by reach-gear design—that is, between the armature pinion and the gear on the axle there is an intermediate gear which merely reaches out to connect the two. This reach gear simply transmits power and does not affect the speed ratio; it enables removal of the motor proper to such distance as to avoid the wheels and permit ample proportions for all parts.

A New Line of Small Centrifugal Pumps

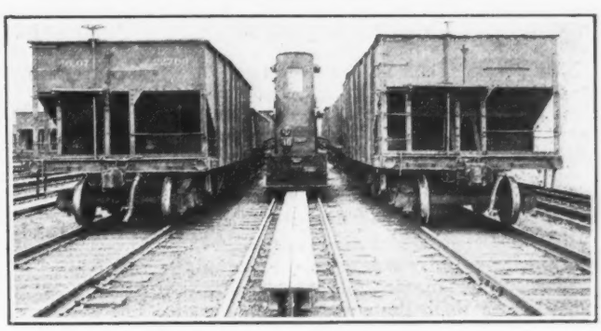
A new series of centrifugal pumps of small size is being introduced by the Wilson-Snyder Manufacturing Co., of Pittsburgh, Pa., to supplement that company's line of larger pumps which it has been manufacturing for twelve years. The new pumps are intended to meet the demand for a high-grade, bronze-fitted, double-suction pump, at a reasonable price. The sensitiveness usually experienced with small centrifugal pumps has been eliminated by the simplicity of design and the ruggedness of construction, proof of which is afforded, it is claimed, by the fact that the pumps during testing were frequently run out of alignment, at high speeds, and with packing excessively tight, without being adversely affected. Complication of design has been avoided. The pumps have been developed to operate with Westinghouse motors at their standard speeds of 1,150 r.p.m. and 1,750 r.p.m. for both d.c. and a.c. current.

Unit Heater of Larger Capacity Introduced

A heating unit having about three times the heating capacity of the original Venturafin unit heater, which was placed on the market last year, is being produced by the American Blower Co., of Detroit, Mich. These heaters make use of a peculiar form of tubular construction. The steam tubes are of thin copper, offering little resistance to the passage of heat. Still higher transmission efficiency is given by winding the tubes with a helical brass "fin," which gives them about three times their ordinary heat-radiating surface.

Spotting Cars With a Pusher Locomotive

The spotting of cars for loading is an interesting process, being accomplished in some instances with the assistance of the General Electric Co.'s pusher type locomotive shown in the cut. These locomotives take a string which may include twenty-five empty cars and move them up into place. After four cars are loaded, they are detached and taken away to be made up in a train. The loaded cars are moved by another locomotive, making the spotter locomotive available at all times for hauling the empty ones, thus eliminating delays in operation.



An electric pusher-type locomotive at work spotting cars for unloading

Trade Catalogs

Road-building Equipment—The January issue of "Novo Power," published by the Nova Engine Co., Lansing, Mich., is devoted to Novo road-building equipment. The February issue will contain several stories concerning Novo industrial hoists.

Electric Tools—Catalog No. 8 of the Black & Decker Manufacturing Co., Towson, Md., contains in its 32 pages a description of the line of portable tools and shop equipment made by the company. This line includes portable electric drills, grinders, valve grinders, tappers, screwdrivers, socket wrenches, post and bench drill stands, electric bench, and pedestal grinders.

Locomotives—The George D. Whitcomb Co., Rochelle, Ill., manufacturers of gasoline, storage-battery, trolley, and combined trolley and storage-battery locomotives, has just issued a new bulletin, No. 2512, covering seven-ton positive gear-driven gasoline locomotives.

Transmission Machinery—The W. A. Jones Foundry & Machine Co., of Chicago, Ill., announces that its new general catalog is off the press. It covers the entire Jones line of power-transmission machinery, showing list prices, dimensions, weights, horsepower ratings, and various other specifications. Copies will be sent free on request to those addressing the company's main office on business stationery.

Motors—Bulletin No. 861, issued by the Electric Machinery Manufacturing Co., of Minneapolis, Minn., is entitled "Synchronous Motors for Pumping." It contains 16 pages and is well illustrated. With it is included a copy of Bulletin 785 A, giving a list of users of E-M synchronous motors.

Pumps—The Worthington Pump & Machinery Corporation, of New York, has just issued a new bulletin, W-607, entitled "Worthington Centrifugal Pumps Serving Every Industry."

Air Classifiers—Bulletin No. 17 of the Hardinge Company, York, Pa., gives details of Hardinge air classifiers, including the rotary air classifier and the combined rotary and superfine classifier, both for use with the Hardinge conical mill.

Unit Heaters—The American Blower Co., of Detroit, Mich., in Bulletin 1,218 describes Venturafin unit heaters of various capacities. These were introduced during 1924.

The Market Report

Daily Prices of Metals

Feb.	Copper N. Y. net refinery*	Tin		Lead		Zinc
	Electrolytic	99 Per Cent	Straits	N. Y.	St. L.	St. L.
5	14.60	57.125	57.625	9.70	9.40	7.50
6	14.75	56.625	57.125	9.70	9.375	7.55@7.65
7	14.75	56.50	57.00	9.70	9.35	7.60
9	14.75	56.375	56.875	9.70	9.225@9.35	7.55@7.625
10	14.625	56.875	57.375	9.70	9.225@9.35	7.50
11	14.60	57.125	57.625	9.70	9.225@9.30	7.40@7.45
Av.	14.679	56.771	57.271	9.70	9.327	7.535

*These prices correspond to the following quotations for copper delivered: Feb. 5th, 14.85c.; 6th, 7th and 9th, 15c.; 10th, 14.875c.; 11th, 14.85c.

The above quotations are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for deliveries constituting the major markets, reduced to the basis of New York cash, except where St. Louis is the normal basing point, or as otherwise noted. All prices are in cents per pound. Copper is commonly sold "delivered," which means that the seller pays the freight from the refinery to the buyer's destination.

Quotations for copper are for ordinary forms of wire bars, ingot bars and cakes. For ingots an extra of 0.05c. per lb. is charged and there are other extras for other shapes. Cathodes are sold at a discount of 0.125c. per lb.

Quotations for zinc are for ordinary Prime Western brands. Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

The quotations are arrived at by a committee consisting of the market editors of *Mining Journal-Press* and a special representative of the Bureau of Mines and the Bureau of Foreign and Domestic Commerce.

London

Feb.	Copper			Tin		Lead		Zinc	
	Standard		Electrolytic						
	Spot	3M		Spot	3M	Spot	3M	Spot	3M
5	65½	66⅝	69½	263½	266½	38⅝	37	36 5/16	35 7/8
6	65½	66⅝	70	262	265	39⅜	38⅛	36¾	36⅜
9	65¼	66¼	70	261½	264¾	38¼	37⅜	36¾	36 5/16
10	65	66	70	262½	265⅝	37⅜	36¾	36 7/16	36
11	64¾	65¾	70	263¾	266¾	37⅝	36⅞	35 7/8	35 7/16

The above table gives the closing quotations on the London Metal Exchange. All prices in pounds sterling per ton of 2,240 lb.

Silver, Gold, and Sterling Exchange

Feb.	Sterling Exchange "Checks"	Silver		Gold London	Feb.	Sterling Exchange "Checks"	Silver		Gold London
		New York	London				New York	London	
5	4 78½	68¾	32¼	87s 1d	9	4.77½	68½	32¼	87s 4d
6	4.78	68½	32⅛	87s 2d	10	4.77⅝	68⅜	32⅛	87s 2d
7	4 76⅝	68⅜	32 3/16	.....	11	4.77½	68½	32¼	86s10d

New York quotations are as reported by Handy & Harmon and are in cents per troy ounce of bar silver, 999 fine. London silver quotations are in pence per troy ounce of sterling silver, 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command one-quarter of a cent premium.

Copper Improves; Other Metals Quiet

New York, Feb. 11, 1925—Sales of copper have been larger in the week ending today, and prices are also better than last week, but no great interest has been taken in the other metals. London prices are closely watched for indications of weakness but on the whole the foreign market has behaved fairly well, the London quotations on all of the metals being a trifle higher today than last Wednesday. Fundamental conditions both in the metal trades and in general business are excellent, and a good year is generally expected by market followers.

Copper Touches 15c. Again

After being sold for as low as 14½c., delivered, as was reported last week, copper took a sudden turn for the better, and most of the sales last Thursday were at 14¾c. This sudden strength was inspired by an advance of a pound and more in London, and consumers here bought heavily on the advance. The speculative lots seem to have been cleared up quickly. By Friday, practically every one was getting 15c. again, with 15¼c. being done in Buffalo and points West. Business at this level continued through Monday, but as inquiries slacked off, two or three interests reduced their prices to 14⅞c. yesterday, especially for near-by copper. Some copper was still sold for 15c., but on the other hand, one good-sized lot went for 14.80c. Today, it might be possible to pick up some February copper, and possibly March too, for 14⅞c., delivered, though the quoted level is 14¾c., and the large producers continue nominally at 15c.

Domestic sales for the week ending today have been better than for some weeks, totaling slightly over 25,000,000 lb. One large consumer was an important buyer, and several 500-ton lots were booked for other brass and wire mills. A pronounced effort seems to have been made to bring the market up to 15c. on Thursday and Friday. This was successful, but that level cannot be maintained without more foreign support than has existed during the last week. Export sales have not been large; on most of the business 14.95@15c., c.i.f. has been realized. Today, the best bid in the f.a.s. market is reported to be 14.70c.

Advance orders of copper fabricators have come in somewhat better during the last two or three weeks, indicating that most of the plants will be able to continue operating at their present pace during the spring months. A prominent brass company reports that January was the best month in its history. As buying of copper has not been particularly good since before the holidays, it would not be surprising to see the volume of sales pick up materially in the next month.

Lead Slightly Weaker

The contract price of the American Smelting & Refining Co. for New York lead continues at 9.75c. That a further reduction has not been made has occasioned some surprise, inasmuch as 9.50c. has been quoted by some other would-be sellers without attracting much attention from consumers, and there is no difficulty in buying lead in the Middle West for around 9¼c. and shipping it East, so that it could be laid down in New York at 9.60c. Sales of moderate amounts have been made at 9.50c. New York, and slightly above, but the amount going to consumers at that level is much less than that being sold on contract at the Smelting company's price.

In the Middle West, producers of chemical lead have found it necessary to revise their prices downward to effect sales, one producer having come down to 9.30c. today, and another having sold for even less than this during the last three days. Corroding lead continues to be quoted at from $2 to $3 per ton above common lead, but the demand has been weak.

Consumers report that business continues excellent, but in view of the increased production by nearly all of the smelters they feel that forward buying is dangerous, so are providing them-

selves with only their early requirements. The key to the problem lies in the foreign demand; if that keeps up on the scale of the last few months, the increased production will probably be none too great to offset the demand.

Zinc in Better Demand

Galvanizers and brass manufacturers have been more active buyers of zinc during the last week, though the total volume of business has not been particularly large. The London market has been somewhat below domestic parity recently, so that but little export business has been done. London prices would probably have dropped much further except for some heavy buying by interests there who had previously sold in that market for future delivery when prices were good. Supplies are said to be somewhat scarce in London today, and higher prices have had to be paid since the close of the market.

The monthly zinc statistics issued by the American Zinc Institute are exceedingly favorable so far as stocks and domestic deliveries are concerned. They are as follows:

	Tons of 2,000 lb.
Stock, Jan. 1	21,208
Produced	50,386
Shipped	52,598
Stock, Jan. 31	18,996
Shipped from plant for export	8,251
Retorts operating, Jan. 31	86,081

The only unfavorable factor is the increase in the number of retorts operating, but this increase seems justified, and if the export demand continues at the rate of 8,000 tons a month or better, which seems reasonable to expect, the market should give a good account of itself.

Prices are about the same for prompt and forward delivery. High-grade continues at 8¾c. delivered.

Tin Quiet and Steady

Since last Wednesday, when buying was quite active, consumers and dealers have taken little interest in the tin market, and prices have hung around 57c. for spot Straits, without any marked tendency in either direction. London operators do not seem inclined to reduce prices much to tempt American consumers, and the market is hardly in shape for a speculative advance. Arrivals of tin to and including Feb. 10 have been 1,175 long tons.

Silver Holds Steady

Silver continues steady, and there appear to be buyers on any declines.

Mexican Dollars: Feb. 5th, 53c.; 6th, 52⅞c.; 7th, 52⅝c.; 9th, 52⅞c.; 10th, 52⅝c.; 11th, 52¾c.

Exchanges Slightly Weaker

Sterling has been rather heavy, and other principal exchanges have declined somewhat. Closing cable quotations on Tuesday, Feb. 10, were: francs, 5.36c.; lire, 4.14c.; and marks, 23.81c. Canadian dollars, $\frac{5}{32}$ per cent discount.

Other Metals

Quotations cover large wholesale lots unless otherwise specified.

Aluminum—99 per cent grade, 28c. per lb.; 98 per cent, 27c. London, £125.

Antimony — Prices have advanced sharply.

Chinese brands, 20c. per lb.

Cookson's "C" grade, 22c.

Chinese needle, lump, nominal, 10c.

Standard powdered needle, 200 mesh, 11½@13c.

White oxide, Chinese, 99 per cent Sb_2O_3, 16@16½c.

Bismuth—$1.30@$1.35 per lb., in ton lots. London, 5s.

Cadmium—60c. per lb. London, 2s. 2d.@2s. 6d.

Iridium—$325 per oz.

Nickel—Ingot, 31c.; shot, 32c.; electrolytic, 38c.; London, £162½ per long ton.

Palladium—$79@$83 per oz. Crude, $60@$65.

Platinum—$117 per oz. for refined. Crude, $113@$115.

Quicksilver — $79@$81 per 75-lb. flask. San Francisco (last quotation received Feb. 4) $81.65. Quiet. London, £13.

The prices of Cobalt, Germanium Oxide, Lithium, Magnesium, Molybdenum, Monel Metal, Osmiridium, Osmium, Radium, Rhodium, Ruthenium, Selenium, Tantalum, Tellurium, Thallium, Tungsten, and **Zirconium** are unchanged from the prices given in the Feb. 7 issue.

Metallic Ores

Chrome Ore—Indian ore, $21@$22 per ton, c.i.f. Atlantic ports.

Tungsten Ore—Per unit, N. Y.:

Chinese wolframite, $9.25@$9.50.

High-grade Western scheelite, $9.50 @$9.75.

Iron Ore, Galena Radio Crystals, Manganese, Molybdenum, Tantalum, and **Vanadium Ores** are unchanged from Feb. 7 quotations.

Zinc Price Advanced—Lead Unchanged

Joplin, Mo., Feb. 7, 1925

Zinc Blende	Per Ton
High	$54.85
Premium, basis 60 per cent zinc	$53.50@ 55.50
Prime Western, 60 per cent zinc	52.50@ 53.50
Fines and slimes, 60 per cent zinc	51.00@ 49.00
Average settling price, all	54.06
Lead Ore	
High	$148.20
Basis 80 per cent lead	125.00
Average settling price, all	137.78

Shipments for the week: Blende, 15,247; calamine, 65; lead, 2,733 tons. Value, all ores the week, $1,202,840.

A large portion of both zinc and lead ore now being settled for was sold before it was produced, when prices ranged much higher than now, accounting for the high average price of each.

At 4 o'clock this afternoon little business had been transacted in the purchase of zinc ore, even at the prices quoted.

Platteville, Wis., Feb. 7, 1925

Zinc Ore	Per Ton
Blende, basis 60 per cent zinc	$53.00
Lead Ore	
Lead, basis 80 per cent lead	$126.00

Shipments for the week: Blende, 745 tons; lead, 40 tons. Shipments for the year: Blende, 3,682; lead, 200 tons. Shipments for the week to separating plants, 1,429 tons blende.

Non-Metallic Minerals

Amblygonite, Asbestos, Barytes, Bauxite, Beryl, Borax, Celestite, Chalk, China Clay, Corundum, Diatomaceous Earth, Emery, Feldspar, Fluorspar, Fuller's Earth, Garnet, Gilsonite, Graphite, Gypsum, Ilmenite, Iron Oxide, Lepidolite, Limestone, Magnesite, Manjak, Mica, Monazite, Ocher, Ozocerite, Phosphate, Potash, Pumice, Pyrites, Quartz Rock Crystals, Rutile, Silica, Spodumene, Sulphur, Talc, Tripoli, and **Zircon** are unchanged from Feb. 7 prices.

Mineral Products

Arsenious Oxide (white arsenic)—**5¾c. per lb.**

Copper Sulphate, Sodium Nitrate, Sodium Sulphate, and **Zinc Oxide** are unchanged from Feb. 7 prices.

Ferro-Alloys

Ferromanganese—Domestic, German, and English, $115 per gross ton, f.o.b. works, or duty paid at seaport.

Ferrocerium, Ferrochrome, Ferromolybdenum, Ferrosilicon, Ferrotitanium, Ferrotungsten, Ferro-uranium and Ferrovanadium are unchanged from the prices given in the Feb. 7 issue.

Metal Products

Rolled Copper — Sheets, 23c.; wire, 17c.

Yellow Metal, Nickel Silver, Lead Sheets and **Zinc Sheets** are unchanged from Feb. 7 issue.

Refractories

Bauxite Brick, Chrome Brick, Firebrick, Magnesite Brick, Magnesite Cement, Silica Brick, and **Zirkite** are unchanged from Feb. 7 prices.

Steel Holds Advance—Pig Iron Dull

Pittsburgh, Feb. 10, 1925

Though there are some changes from week to week in operations at various mills, the general rate of the steel industry seems to be close to 90 per cent. This indicates more steel than normal full requirements, as indicated by past performances, and some decrease in production, perhaps only a small one, is to be expected.

Recent steel price advances were made partly to stimulate specifying on old contracts and buying at the prices being displaced, and the operation has been more or less successful. The new prices have not been tested to any extent, but may hold through mills seeing no advantage in cutting them. The advance in bars, shapes, and plates to 2.20c., Pittsburgh, became effective more than a week ago.

Recent sales of sheet bars at $39 are regarded as making the market at that figure, against the old price of $37 and a recent asking price of $40.

Pig Iron—The market has continued dull, but is fairly steady. Bessemer, $23; basic, $22; foundry, $22@$23, f.o.b. Valley furnaces.

Connellsville Coke—Spot furnace is slightly higher, at $3.85@$4, spot foundry remaining at $4.75@$5.25. There are no contract negotiations.

Freight Rates on Metals, Ores, and Concentrates

Carload Lots

Copper Bullion and Refined Copper

From	To	Rate per Ton of 2,000 Lb. All Rail	Via Gulf
El Paso, Tex.	Baltimore, Md.	$11.40	$10.00
Garfield, Utah	Perth Amboy	12.50	.....
Garfield, Utah	San Francisco	5.85	.....
Hayden, Ariz.	Perth Amboy	14.50	12.50
Miami, Ariz.	Perth Amboy	14.50	12.50
Anaconda, Mont.	Perth Amboy	12.50	.....
Butte, Mont.	Perth Amboy	12.50	.....
Humboldt, Ariz.	Chrome, N. J.	14.50	12.50
Douglas, Ariz.	Perth Amboy	14.50	12.50
Globe, Ariz.	Perth Amboy	14.50	12.50
Clifton, Ariz.	Perth Amboy	14.50	12.50
Clarkdale, Ariz.	Chrome, N. J.	14.50	12.50
Copperhill, Tenn.	Laurel Hill, N. Y.	$10.80	.....
Tooele, Utah	Chrome, N. J.	12.50	.....
McGill, Nev.	Baltimore, Md.	15.90	.....
Houghton, Mich.	New York	(a) 11.40	.....
Hancock, Mich.	New York	(a) 11.40	.....
Hubbell, Mich.	New York	(a) 11.40	.....
Dollar Bay, Mich.	New York	(a) 11.40	.....
Tacoma, Wash.	New York Conference rate via Canal		$6.00
Anaconda, Mont.	Tacoma, Wash.	7.09	.....
Ajo, Ariz.	New York	14.50	$12.50

(a) Applies Dec. 1 to Mar. 31.

Marine Freight Rates

New York to
- Hamburg: *$4.50 per gross ton copper and lead
- Liverpool: 5.50 per gross ton copper and lead
- Antwerp: *4.00 per gross ton copper and lead
- Havre: 4.75 per gross ton lead; 5.00 per gross ton copper

Gulf ports to
- Hamburg: *$4.50 per gross ton copper and lead
- Liverpool: 5.50 per gross ton copper and lead
- Antwerp: *4.00 per gross ton copper and lead
- Havre: 5.00 per gross ton copper

Pacific coast ports to
- Hongkong: $6.00 per short ton copper and lead
- Kobe: 6.00 per short ton copper and lead

Lead Bullion (Pig Lead Where Shown)

From	Rates per Ton of 2,000 Lb. To New York	To St. Louis
East St. Louis, Ill.	$7.00	.....
Pueblo, Colo.	*12.50	*$9.00
Leadville, Colo.	12.50	*9.00
East Helena, Mont	12.50	9.50
El Paso, Tex.	10.00 Via Gulf	
	12.00 All Rail	7.00
Omaha, Neb.	9.60	3.65
Murray, Utah	12.50	9.00
Midvale, Utah	12.50	9.00
Tooele, Utah	12.50	9.00
East Chicago, Ill.	(b) 6.00	(a) 1.60
Kellogg, Idaho	13.50	9.50
Carnegie, Pa.	3.80	(a) 5.00
Selby, Calif.	(b) 6.00	.....
Herculaneum, Mo.	(a) 8.80	(a) 1.80
Federal, Ill.	7.00	(a) 1.80
Collinsville, Ill.	7.00	(a) .75½
Granby, Mo.	(a) 10.50	(a) 3.50
Joplin, Mo.	(a) 10.50	(a) 3.50

(a) Pig lead only.
(b) Conference rate, via canal.

Slab Zinc

From	Rates per Net Ton to E.St. Louis	New York
Donora, Pa.	(a) $4.60	$3.80
Langeloth, Pa.	(a) 4.60	3.80
Palmerton, Pa.	7.10	3.00
Hillsboro, Ill.	1.40	7.00
Danville, Ill.	1.60	6.40
La Salle, Ill.	1.60	6.70
Springfield, Ill.	3.00	7.00
Cleveland, Ohio	5.80	5.00
Moundsville, W. Va.	4.40	3.80
Van Buren, Ark.	3.80	10.80
Fort Smith, Ark.	3.80	10.80
Bartlesville, Okla.	3.50	10.50
Blackwell, Okla.	3.80	10.80
Henryetta, Okla.	3.80	10.80
Sand Springs, Okla.	3.80	10.80
Cherryvale, Kan.	3.50	10.50
Black Eagle, Mont.	9.40	12.50
Park City, Utah	9.00	12.50

(a) To St. Louis, Mo.

Zinc Ores and Concentrates

To	From	Rate per Net Ton
Bartlesville, Okla.	Altoona, Kan.	$2.10
	Pittsburg, Kan.	1.09
	Galena, Kan.	1.30
	Joplin, Mo.	1.40
	Iola, Kan.	1.09
	Baxter, Kan.	1.40
	Miami, Okla.	1.40
	Quapaw, Okla.	1.40
	Kansas City, Mo.	1.60
Sand Springs, Okla.	Miami, Okla.	2.20
	Quapaw, Okla.	2.20
	Galena, Kan.	1.50
	Joplin, Mo.	1.50
	Iola, Kan.	2.40
Dewar, Okla.	Cave Springs, Mo.	2.00
	Cent City Spur, Mo.	2.00
Kusa, Okla.	Chitwood, Mo.	2.00
Henryetta, Okla.	Galena, Kan.	1.50
	Iola, Kan.	2.40
	La Harpe, Kan.	2.40
La Harpe, Kan.	Mound City, Kan.	.50
	Oswego, Kan.	.50
	Parsons, Kan.	.50
Coffeyville, Kan.	Galena, Kan.	1.10
	Joplin, Mo.	1.22
Bartlesville, Okla. (a)	Baxter, Kan.	1.80
	Miami, Okla.	1.80
	Quapaw, Okla.	1.80

(a) Lead ore and concentrates.

Rates on Ores and Concentrates

From	To	Value of Product: $5	$10	$15	$20	$25	$30	$35	$40	$50	$60	$70	$75	$80	$90	$100
		Rate														
Butte, Mont.	Anaconda, Mont.	.22	.22	.22	.22	.22	.22	.22	.22	.22	.22	.22	22	.22	.22	.22
Butte, Mont.	Black Eagle, Mont. (a)	....	....	....	....	....	....	....	1.01	....	....	....	....	....	....	1.01
Great Falls, Mont.	East Helena, Mont.	....	....	1.57	....	1.76	....	1.98	....	2.43	....	....	....	....	....	2.55
Butte, Mont.	East Helena, Mont.	....	....	1.17	....	1.46	....	1.69	....	2.03	....	....	....	....	....	2.14
Paxton, Calif.	Salt Lake Smelters, Utah	....	....	....	....	....	....	....	....	6.30	7.00	7.70	....	8.35	8.60	8.85
Johannesburg, Calif.	Selby, Calif.	....	....	....	2.90	....	3.50	....	4.10	4.70	5.30	5.90	....	6.50	6.80	7.10
Johannesburg, Calif.	Humboldt, Ariz.	....	....	....	3.40	....	4.10	....	4.80	5.50	6.20	6.90	....	7.60	8.00	8.30
Pioche, Nev.	Humboldt, Ariz.	....	4.50(c)	7.74	....	8.55	....	9.36	....	9 99	....	....	11.25	....	....	12.42
Creede, Colo.	Durango, Colo.	....	....	3.25	3.50	3.75	4.00	....	4.25	4.75	5.25	5.75	6.05	....	....	7.10
Ouray, Colo.	Durango, Colo.	....	....	4.30	4.80	....	5.05	....	....	5.90	....	6.30	....	....	....	7.70
Kokomo, Colo.	Durango, Colo.	....	6.00	....	....	6.50	7.20	....	....	....	....	....	....	....	....	....
Telluride, Colo.	Durango, Colo.	....	....	....	....	....	4.30	....	5.00	5.50	6.00	6.30	....	6.60	7.10	7.70
Silverton, Colo.	Durango, Colo.	....	....	1.40	1.40	....	....	2.20	....	....	2.30	2.55	....	2.80	....	2.80
Tyrone, N. M.	Douglas, Ariz.	....	....	1.60	1 90	....	2.20	....	2.50	2 80	....	....	3 10	....	....	3.40
Tyrone, N. M.	El Paso, Tex.	....	....	1.60	1 90	....	2.20	....	2.50	2 80	....	....	3.10	....	....	3.40
Lordsburg, N. M.	Douglas, Ariz.	....	1.00	1.30	1.60	....	1.90	....	2.20	2 50	....	....	2.80	....	....	3.40
Lordsburg, N. M.	El Paso, Tex.	....	1.00	1.30	1.60	....	1.90	....	2.20	2.50	....	....	2.80	....	....	3.40
Tombstone, Ariz.	Douglas, Ariz.	....	....	.60	....	.90	....	....	....	1.30	....	....	1.60	....	....	1.90
Tombstone, Ariz.	El Paso, Tex.	....	....	1.90	....	2.50	....	....	....	3.80	....	....	4.40	....	....	4.40
Silver City, N. M.	Douglas, Ariz.	....	....	2.48	....	3.15	....	....	....	3.83	....	....	....	....	....	5.29
Ray Junction, Ariz.	Hayden, Ariz.	....	.10	....	.40	....	.50	....	.80	.90	....	....	1.00	....	....	1.10
Sandon, B. C. / Alamo Concentrator, B. C.	Tadanac, B. C.	1.50	1.60	1.70	1.90	2.00	2.50	....	2.60	2 90	3.40	3.50	....	3.70	3.80	3.90
Rossland, B. C.	Tadanac, B. C.	.90	.90	1 00	1.00	1.10	1.50	....	1.60	1.60	1.60	1.70	....	1.70	1.70	1.70
Rossland, B. C.	Tadanac, B. C(d).	.30	.30	.30	.30	.50	.70	....	.80	.80	....	....	....	....	....	....
Republic, Wash.	Tadanac, B. C.	....	2.02	2.50	2.66	2.86	3.84	....	3.84	3.84	4.69	4.89	....	5.19	5.39	5.59

(a) Minimum tonnage of 200 tons per day. (b) In open cars, minimum 80,000 lb. (c) Siliceous ore tailing.
(d) Applicable on ore, only when shipped in trainload lots of not less than 10 cars and exclusive of switching charges at Rossland.

From	To	Value of Ores and Concentrates: $10	$15	$20	$25	$30	$35	$40	$50	$60	$70	$75	$80	$90	$100
		Rate													
Burke, Idaho (a)	Bradley, Idaho	....	....	....	....	....	....	....	....	.68	....	.....	....	....	1.02
Burke and Wallace, Idaho (d)	East Helena, Mont.	....	....	....	....	3.00	....	3.25	3.50	3.75	4.00	.....	4.25	4.50	4.75
Sagel, Idaho	East Helena, Mont.	....	....	....	3.38	....	3.83	....	4.16	....	....	....	....	....	4.84
Arizona Tunnel, Idaho	Bradley, Idaho	....	....	....	....	....	....	....	....	.35	....	....	....	....	.50
Bayview, Idaho	Bradley, Idaho	....	....	....	....	....	....	....	3.75	....	....	4.37½	....	....	5.12½
Park City, Utah	Salt Lake Smelters	1.00(e)	1.10	1.25	....	1.50	....	1.75	....	2.00	....	.....	2.25	....	2.50
Eureka, Utah	Salt Lake Smelters	1.00	....	1.25	....	1.50	....	1.75	2.00	2.25	2.50	.....	2.75	3.00	3.25
Tintic, Utah	Salt Lake Smelters	1.00	....	1.25	....	1.50	....	1.75	2.00	2.25	2.50	.....	2.75	3.00	3.25
St. Johns, Utah	Salt Lake Smelters	1.00	....	1.25	....	1.50	....	1.75	2.00	2.25	2.50	.....	2.75	3.00	3.25
Ophir, Utah	Salt Lake Smelters	1.00	....	1.25	....	1.50	....	1.75	2.00	2.25	2.50	.....	2.75	3.00	3.25
Bingham, Utah	Garfield, Utah	....	.40	....	.75	....	....	....	.95	....	....	1.10	....	....	1.25
Cherry Creek, Nev.	Garfield, Utah (c)	....	....	4.60	....	5.10	....	5.60	6.10	6.60	7.10	.....	7.60	8.10	8.60
Cherry Creek, Nev.	Garfield, Utah (b)	....	....	3.20	....	3.90	....	4.60	5.30	6.00	6.70	.....	7.40	....	....
Goldfield, Nev.	Salt Lake Smelters	....	4.15	5.10	....	5.80	....	6.50	7.20	7.90	8.60	.....	9.30	10.00	10.70
Battle Mountain, Nev. (a)	Salt Lake Smelters	....	4.15	3.20	....	3.80	....	4.40	5.00	5.60	6.20	.....	6.80	7.40	8.00
Palisade, Nev. (a)	Salt Lake Smelters	....	2.90	3.20	....	3.80	....	4.40	5.00	5.60	6.20	.....	6.80	7.40	8.00
Mina, Nev. (a)	Salt Lake Smelters	....	....	3.60	....	4.30	....	5.00	5.70	6.40	7.10	.....	7.80	8.50	9.20
Lovelock, Nev. (a)	Salt Lake Smelters	....	....	3.20	....	3.90	....	4.60	5.30	6.00	6.70	.....	7.40	8.10	8.80
Golconda, Nev. (a)	Salt Lake Smelters	....	....	3.20	....	3.90	....	4.60	5.30	6.00	6.70	.....	7.40	8.10	8 80
Hazen, Nev. (a)	Salt Lake Smelters	....	....	3.20	....	3.90	....	4.60	5.30	6.00	6.70	.....	7.40	8.10	8 80
Tonopah, Nev.	Salt Lake Smelters	....	4.15	5.10	....	5.80	....	6 50	7.20	7.90	8.60	.....	9.30	10.00	10 70
Rogerson, Idaho	Salt Lake Smelters	3.00	....	3.50	....	4.00	....	4.50	5.00	5.50	6.00	.....	6.50	7.00	7 50
Georgetown, Colo.	Leadville, Colo.	....	....	3.50	....	3.75	....	4 00	5.00	5.00	5 80	.....	5.80	5.80	5 80
Shirley, Colo.	Leadville, Colo.	....	....	2.25	....	2.25	....	2.25	2.25	4 30	4.30	.....	4.30	4.30	4.30

(a) Minimum weight, marked capacity of car used, but not less than 80,000 lb. (b) Minimum weight, 80,000 lb. (c) Minimum weight, 40,000 lb.
(d) Crude ore for concentration, 30c. per ton, effective July 7.
(e) For $9 value rate is 95c.; $8 value, 90c.; $7 value, 85c.; $6 value, 80c.
* Indicates a change of tariff since last report.

Imports and Exports of Ores and Metals in December, 1923 and 1924

Imports and exports of certain metals and ores during December, 1924, with revised comparative figures for December, 1923, as compiled by the U. S. Department of Commerce, are as follows:

Imports

In Pounds, Unless Otherwise Stated

	December, 1923	December, 1924
Antimony		
Ores	331,873	167,098
Liquated, regulus or metal	1,594,975	1,391,869
Copper		
Ore	9,480,674	6,466,689
Concentrates	4,403,251	4,106,731
Regulus, coarse metal and cement copper	.....	4,506,631
Total	13,883,925	15,080,051
Imported from:		
Spain	3,152,765	810,672
Canada	32,433	935,785
Mexico	1,721,619	2,572,550
Cuba	3,332,723	3,360,000
Chile	4,486,649	5,612,801
Colombia	45	.....
Peru	194,947	248,277
Venezuela	351,254	1,137,920
Other countries	611,490	402,046
Unrefined, black, blister and converted copper in pigs, bars and other forms	19,421,076	37,707,825
Imported from:		
Spain	244,073	.....
United Kingdom	21,304	1,380,079
Canada	1,075,520	2,285,234
Mexico	5,048,374	5,237,403
Chile	5,699,913	10,038,869
Peru	4,469,511	3,848,815
Portuguese Africa	6,364,020	7,559,769
Other countries	1,628,361	7,357,656
Refined copper	19,593,574	9,104,925
Old and clippings, for remanufacture	251,441	793,679
Composition metal, copper chief value	.....	.....
Copper manufactures	45,850	7,038
Brass		
Old and clippings for remanufacture	684,772	1,149,942
Manufactures of brass	101,585	71,458
Lead		
Ore and matte	8,968,819	7,708,438
Bullion or base bullion	16,471,058	10,568,753
Pigs, bars, other forms, and old	67,797	273,187
Manufactures of, except type metal	43,770	24,496
Manganese ore, long tons	12,003	18,522
Pyrites, long tons	25,010	23,598
Tin		
Tin ore, tons	15	44
In blocks, bars and pigs	12,337,358	11,737,511
Imported from:		
British Straits Settlements	8,052,608	7,918,098
United Kingdom	2,635,414	2,174,674
Dutch East Indies	340,980	.....
Hongkong	992,457	20,142
Australia	11,200	112,000
Other countries	304,699	1,512,597
Zinc		
Ore—Free	68,014	
Dutiable	4,242,995	1,428,107
Blocks, pigs, and other forms	1,302	11,320
Zinc dust	7,101	62,185

Exports of Copper, Lead, and Zinc

In Pounds

	December, 1923	December, 1924
Copper		
Ores, concentrates, matte, and regulus	.....	26,484
Copper and manufactures of	77,260,167	97,462,529
Refined in ingots, bars and other forms	70,170,983	88,464,760
Exported to:		
Belgium	3,498,900	6,165,881
France	23,437,428	15,363,754
Germany	7,447,471	24,841,407
Italy	6,960,126	8,421,038
Netherlands	930,275	12,275,945
Spain	134,419	775,387
Sweden	3,746,388	1,681,995
United Kingdom	13,068,777	14,830,845
Canada	1,019,655	1,164,860
British India	665,848	1,010,579
China	4,346,181	672,000
Japan	3,919,638	447,918
Other countries	995,877	813,151
Old and scrap copper	223,082	962,473
Composition metal, copper chief value	717	1,110
Pipes and tubes	177,442	132,906
Plates and sheets	164,743	361,269
Rods	4,298,910	5,924,254
Wire	1,320,506	475,321
Insulated copper wire and cable	690,627	987,664
Other manufactures of copper	213,157	152,772
Lead		
Pigs, bars and other forms:		
From domestic ore	91,421	383,407
From foreign ore	11,398,066	20,859,462
Exported to		
France	3,024,759	1,344,615
Germany	616,257	2,632,867
Netherlands	896,176	448,020
United Kingdom	5,903,702	13,652,222
Other Europe	560,198	2,240,686
Argentina	168,007	359,229
Brazil	224,065	470,426
Other countries	96,323	94,804

Exports—Continued

	December, 1923	December, 1924
Zinc		
Ores, concentrates, and dross	1,494,200	1,755,578
Zinc (spelter) in slabs, blocks, or pigs	4,273,084	29,349,168
Exported to		
Belgium	.....	1,736,735
France	1,344,412	2,285,535
Germany	.....	728,459
Italy	616,050	1,120,351
United Kingdom	1,848,423	18,633,315
Canada	1,849	92,051
Other countries	462,350	4,752,722
In sheets, strips, etc	671,030	399,275
Zinc dust	660,236	369,911
Other zinc manufactures	195,368	119,114

German Metal Industries Less Active

By Dr. James Rubinfeld
Charlottenburg, Germany

In January some slight slowing down of demand from users of metals occurred. Consumers are meanwhile well booked with orders for several months, and the rate of copper consumption may be assumed to be 15,000 metric tons or thereabouts monthly, against 6,000 on the average of 1923. Now that the customs authority has been fully restored in the Ruhr and Rhine, I shall be able in future to give more exact details about consumption of copper as well as other metals here which are coming in from Rotterdam. This is the more important, as many leading cable and brass manufacturers and engineering firms are situated in the western provinces. The cable makers have received good orders from the Postal Ministry, whereas the railroads, which, in normal times, are the best customers of rolling and engineering firms, are compelled to conserve their resources owing to obligations incident to paying the first interest installment of about 100,000,000 goldmarks due March 1.

There is a marked shortage of old material here, because of the depletion of domestic and foreign ammunition supplies, so that it is planned to buy old American vessels of the U. S. Shipping Board type to remedy the shortage. Meanwhile the competition on the reviving German market is becoming more and more acute, and the Metallgesellschaft, of Frankfort-on-Main, in complaining of this severe competition of "nearly all foreign producing firms" (as I may quote), which of course compels the domestic trading houses to figure closely and to develop arbitrage business, which is characteristic of German trading. In directing attention to this matter it is pertinent to emphasize the fact that great foreign interests are now vested in the Metallgesellschaft as in other important metal firms of Germany, and the sister firm the Metallbank has thus been able recently to merge with the important cable manufacturer Heddernheimer Kupferwerke, near Frankfort, and to reorganize the Norddeutsche Affinerie, near Hamburg.

Many refineries which until now had been closed down are resuming work, especially smelters of secondary lead and zinc. The scarcity of secondary lead had become so stringent that as much was paid for old as for new metal.

Although the use of copper is increasing, that of aluminum increases likewise. The Bavarian Inn-Werk has recently been opened, and it will add another 800 tons or so of aluminum monthly to the quantities which are being turned out by the Lauta-Werke and Erftwerke. At least 30,000 metric tons a year will be put on the market by this young German industry—a rapid development. All belong to the Reich, which holds now an important bauxite mine in northern Italy for the supply of the electrolytic works with all the raw material that they need. Thus they are no more dependent on French deliveries. There exists still some fear of American dumping by the way of Norwegian deliveries, but so long as the Aluminum Company of America controls United States markets no immediate danger threatens.

The Reich has decided to coin further 300,000,000 gold marks of silver, but it will not need to acquire anew the white metal from American sources, because the stock accumulated recently by the Treasury will suffice.

Sales of futures on the Hamburg and Berlin metal exchanges will probably start in mid-February, and it is expected that at this date petty formalities standing in the way of expanding this business will have disappeared. The big joint-stock bank, Commerz-und Privatbank, will take over the rôle of the clearing office for time transactions. It is believed here that the Metal Exchange of London will at the start help to facilitate German time business.

Mining Stocks

Week Ended February 7, 1925

Stock	Exch.	High	Low	Last		Last Div.
COPPER						
Alaska-Br. Col.	N. Y. Curb			*6		
Anaconda	New York	46	43⅞	46	Ja.17, Fe.16,	0.75
Arcadian Consol.	Boston	2⅛	2⅛	2⅛		
Ariz. Com'l.	Boston	15⅛	12⅛	15⅛	Ja. 19, Ja. 31	0.50
Calaveras	N. Y. Curb	2	2	2		
Calumet & Arizona	New York	54⅛	52⅛	54⅛	De.5, De.22 Q	0.50
Calumet & Hecla	Boston	17	16⅛	16⅛	Ja.30, Mh.4	0.50
Canario Copper	N. Y. Curb	4	3⅞	4		
Cerro de Pasco	New York	54⅛	53	54⅛	Ja. 22, Fe. 2, Q	1.00
Chile Copper	New York	37⅛	35⅞	37⅛	Mh.3,Mh.20, Q	0.62½
Chino	New York	27⅛	24⅛	27⅛	Sept., 1920	0.37½
Con. Coppermines	N. Y. Curb	3⅛	3⅛	3 7/8		
Copper Range	Boston	30⅛	29⅛	30⅛	May, 1924	1.00
Crystal Copper	Boston Curb	*71	*62	*67		
Davis-Daly	Boston	*75	*68	*75	Mar., 1920	0.25
East Butte	Boston	6	5⅛	6	Dec., 1919	0.50
First National	Boston Curb	*28	*28	*28	Feb., 1919	0.15
Franklin	Boston	1⅛	1	1⅛		
Gadsden Copper	Boston Curb	*80	*75	*78		
Granby Consol.	New York	20⅝	19	20⅛	May, 1919	1.25
Greene-Cananea	New York	19	16⅛	18⅛	Nov., 1920	0.50
Hancock	Boston	1⅛	1⅛	1⅛		
Howe Sound	N. Y. Curb	3⅛	3⅛	3⅛	April 1924	0.05
Inspiration Consl.	New York	30⅛	29⅛	30⅛	De.20, Ja.7, Q	0.50
Iron Cap	Boston Curb	2	1⅞	1⅞	May, 1923	0.15
Isle Royale	Boston	18⅛	17	18⅛	Sept. 1923	0.50
Jerome Verde Dev	N. Y. Curb	1⅛	1⅛	1⅛		
Kennecott	New York	56	53⅛	56	Mh.6, Ap.1, Q	0.75
Keweenaw	Boston			*99		
Lake Copper	Boston	3	2⅞	3		
Magma Copper	New York	42⅛	39⅛	41⅛	Jan., 1919	0.50
Mason Valley	N. Y. Curb	2⅛	2⅛	2⅛		
Mass Consolidated	Boston			*90	Nov., 1917	1.00
Miami Copper	New York	23⅛	22	22⅛	Fe.2 Fe.16 Q	0.50
Mohawk	Boston	39⅛	36⅛	37⅛	Ja. 13, Mh. 2	1.00
Mother Lode Coa.	New York	8⅛	8⅛	8⅛	De. 12, De. 31	0.37½
Nevada Consol.	New York	15⅛	14⅞	15⅛	Sept., 1920	0.25
New Cornelia	Boston	23⅛	22⅛	23⅛	Fe. 6, Fe. 23	0.25
New Dominion	N. Y. Curb			2⅛		
North Butte	Boston	2⅞	2⅞	2⅞	Oct., 1918	0.25
Ohio Copper	N. Y. Curb	1 1/8	1 1/8	1 1/8	No.14, De.2	0.05
Old Dominion	Boston	26	23⅛	24⅛	Dec., 1918	1.00
Phelps Dodge	Open Mar.	†125	†120		De.2, Ja.2 Q	1.00
Quincy	Boston	34⅛	31½	34⅛	Mar., 1920	1.00
Ray Consolidated	New York	17	14⅛	16⅛	Dec., 1920	0.25
Ray Hercules	N. Y. Curb	*10	*8	*8		
St. Mary's Min. Ld.	Boston	45⅛	44	45⅛	May 1924	3.00
Seneca Copper	New York	⅜	¼	⅜		
Shannon	Boston	1⅛	1⅛	1⅛	Nov., 1917	0.25
Shattuck Arizona	New York	7⅛	7	7	Jan., 1920	0.25
Superior & Boston	Boston	1⅛	1 1/16	1⅛		
Tenn. C. & C.	New York	9⅛	8⅛	9⅛	De.31, Ja.15,Q	0.25
United Verde Ex.	N. Y. Curb	28	26⅛	28	Ja. 2, Fe. 2	0.50
Utah Copper	New York	90⅛	88⅛	90	De.12, De.31,Q	1.00
Utah Metal & T.	Boston	1	*85	*93	Dec., 1917	0.30
Victoria	Boston	1⅛	*80	1		
Walker Mining	N. Y. Curb			3 1/16		
Winona	Boston	*20	*20	*20		
NICKEL-COPPER						
Internat. Nickel	New York	28⅛	27⅛	27⅛	March, 1919	0.50
Internat. Nickel pfd.	New York	99⅛	97	99⅛	Ja. 15, Fe. 2, Q	1.50
LEAD						
Carnegie Lead & Zinc	Pittsburgh	8	6⅛	7⅛		
National Lead	New York	158⅛	156	157⅛	De.12, De.31, Q	2.00
National Lead pfd.	New York			117⅛	Fe.2, Mh.14, Q	1.75
St. Joseph Lead	New York	44⅛	42⅛	43⅛	De. 9, De. 20	0.50
ZINC						
Am. Z. L. & S.	New York	10⅛	10⅛	10⅛	May, 1920	1.00
Am. Z. L. & S. pfd.	New York	34⅛	33⅛	34	Nov., 1920	1.50
Butte C. & Z.	New York	8⅛	8	8⅛	De.10, De.24	0.50
Butte & Superior	New York	22⅛	19⅛	22⅛	June, 1923	0.50
Callahan Zn-Ld.	New York	4	3⅛	4	Dec., 1920	0.50
New Jersey Zn.	N. Y. Curb	192⅛	191	192⅛	Ja.20, Fe.10	2.00
United Zinc	N. Y. Curb			*15		
Yellow Pine	Los Angeles			*68	De.10,De.15 Q	0.04
SILVER						
Alvarado	Boston Curb			1⅛	Oct. 1920	0.50
Beaver Consol.	Toronto	*33⅛	*31	*32⅛	May, 1920	0.03
Castle-Trethewey	Toronto	*75	*71½	*74½		
Coniagas	Toronto			2.27	May, 1924	0.12½
Keeley	Toronto	2.30	2.29	2 29	Fe.28, Mh.15	0.08
K rr Lake	N. Y. Curb	1⅛	1⅛	1⅛	Oc. 1, Oc. 15,	0.12½
La Rose	Toronto	*44⅛	*36½	*44	Apr., 1922	0.10½
Lorrain Trout Lake	Toronto	1.28	1.16	1.24		
McKinley-Dar.-Sav.	Toronto	*23⅛	*17⅛	*21⅛	Oct., 1920	0.03
Mining Corp. Can.	Toronto	2.68	2.60	2.65	Sept., 1919	0.12½
Nipissing	N. Y. Curb	6⅛	6⅛	6⅛	Ja.18,Ja.20,QX	0.30
Ontario Silver	New York	5⅛	5⅛	5⅛	Jan., 1919	0.50
Temiskaming	Toronto	*24	*23	*23	Jan., 1920	0.40
GOLD						
Alaska Gold	New York			*25		
Alaska Juneau	New York	⅛	⅛	⅛		
Argonaut	Toronto	*45⅛	*37	*45⅛		
Carson Hill	Boston	*50	*50	*50		
Consol. W. Dome L.	Toronto	*18⅛	*16⅛	*18⅛		
Cresson Consol. G.	N. Y. Curb	3⅛	3⅛	3⅛	De.31, Ja.10 Q	0.10
Crown Reserve	Toronto	*50⅛	*45⅛	*50	Jan. 1917	0.05
Dome Mines	New York	15⅛	15	15	De.31, Ja.20, Q	0.50
Golden Cycle	Colo. Springs			1.40	Dec.11, 1924	0.03
Hollinger Consol.	Toronto	14.85	14.60	14.80	Fe.9, Fe.26, M	0.05
Homestake Mining	New York	45	44	44	Fe.20,Fe.25,M	0.50
Jib. Cons l.	N.Y. Curb	*42	*35	*41		
Kirkland Lake	Toronto	*43	*39⅛	*41		
Lake Shore	Toronto	5.00	4.85	4.98	De.1, De.15,XQ,	0.10
McIntyre-Porcupine	New York	16⅛	16⅛	16⅛	Fe.2, Mh.2,	0.25
Newray	Toronto	*25⅛	*25	*25		
Night Hawk Pen.	Toronto	*45	*28	*35		
Portland	Colo. Springs			*44	Oct., 1920	0.01
Rand Mines	New York	*35	*34⅛	*34⅛	Aug. 1924	1.71
Teck-Hughes	Toronto	1.34	1.29	1.33		
Tom Reed	Los Angeles			*57⅛	Dec., 1919	0.02
Tough-Oakes	Toronto	*37	*35⅛	*36⅛		
United Eastern	N. Y. Curb	*55	*50	*54	July, 1924	0.05
Vipond Cons.	Toronto	1.31	1.26	1.30		
Wright-Hargreaves	Toronto	4.34	4.27	4.32	De.15, Ja.2,QX	0.05
GOLD AND SILVER						
Black Oak	N. Y. Curb			*81		
Con. Cortez	N. Y. Curb	*10	*10	*10		
Con. Virginia	San Francisco			6		
Continental Mines	N. Y. Curb			1⅛		
Dolores Esperanza	N. Y. Curb	*55	*45	*55	July, 1923	0.05
Premier Gold	N. Y. Curb	2⅛	2⅛	2⅛	De.22, Ja.5,QX	0.10
Tonopah Belmont	N. Y. Curb	*60	*54	*60	Apr., 1923	0.05
Tonopah Divide	N. Y. Curb	*36	*33	*33	Se. 22, Oc. 10	0.10
Tonopah Extension	N. Y. Curb	3	2⅞	3	De.11, Ja.1	0.05
Tonopah Mining	N. Y. Curb	2⅛	1⅛	2 1/16	Ap. 1, Ap. 21,	0.07½
Unity Gold	N. Y. Curb	*65	*60	*60		
West End Consol.	N. Y. Curb			*46	Mar., 1923	0.05
Yukon Gold	N. Y. Curb			*45	June, 1918	0.02
SILVER-LEAD						
Ahumada	Boston Curb	10⅜	9⅛	10⅛	De.15, Ja.2, X	0.15
Bingham Mines	Boston	32⅛	32	32⅛	De.20, Ja.2	0.50
Cardiff M. & M.	Salt Lake	1.70	1.70	1.70	De.16, No.18	0.10
Chief Consol.	Boston Curb	3⅛	3⅛	3⅛	May, 1924	0.10
Columbus Rexall	Salt Lake	*25	*23⅛	*23⅛	Aug., 1923	0.05
Daly Mining	Salt Lake			1.50	July, 1920	0.10
Erupcion	Boston Curb	3⅛	3	3⅛	De.15, Ja.2, X	0.15
Federal M. & S.	New York	23⅛	23⅛	23⅛	Jan., 1909	1.50
Federal M. & S. pfd.	New York	62⅛	60⅛	62⅛	No.25, De.15,	1.75
Florence Silver	Spokane	*4⅛	*4	*4⅛	Apr., 1919, QX	0.01
Hecla Mining	New York	16⅛	14	15⅞	No.15, De.15	0.25
Iron Blossom Con.	N. Y. Curb			*29	Oc.25, 1924	0.02½
Marsh Mines	N. Y. Curb			*6	June, 1921	0.02½
Park City	Salt Lake	4.90	4.90	4.90	De. 15, Ja. 2	0.15
Park Utah	Salt Lake			⅜	April, 1924	0.15
Prince Consol.	Salt Lake	*34	*33	*33		
Silver King Coal	Salt Lake	5.45	5.30	5.45	De.20, Ja.2, Q	0.20
Silversmith	Spokane	*30	*28⅛	*28⅛	Ja. 1, Ja. 10	0.02
Tamarack-Custer	Spokane	*84	*80	*82	Se. 22, Se. 29	0.25
Tintic Standard	Salt Lake	9.30	9.20	9.20	Ja.2, QX	0.50
Utah-Apex	Boston	6⅛	6⅛	6⅛	Ja.10, Ja.15,	0.25
IRON						
Bethlehem Steel	New York	51⅛	50⅛	50⅛	Jn.1, Jy.1, Q	1.25
Char. Iron	Detroit			*20		
Char. Iron pfd	Detroit			*74		
Colorado Fuel & Iron	New York	47⅛	44⅛	46⅛	May, 1921	0.75
Gt. North'n Iron Ore	New York	39⅛	38⅛	38⅛	De.10, De.27	2.00
Inland Steel	New York	50	48⅛	48⅛	Fe.14, Mh.20 Q	0.625
Mesabi Iron	N. Y. Curb	3⅛	3⅛	3⅛		
Replogle Steel	New York	21⅛	19	20		
Republic I. & S.	New York	60⅛	57	58⅛	May, 1921	1.50
Republic I. & S. pfd.	New York	94⅛	93⅛	94	Mh.8, Ap.1, Q	1.75
Sloss-Sheffield S. & I.	New York	97	86⅛	95	Mh.10, Mh.20	Q 1.50
Sloss-Shef. S.&I. pfd.	New York	98⅛	97⅛	98	Mh.20, Ap.2, Q	1.75
U. S. Steel	New York	128⅛	123⅛	127⅛	Fe.28,Mh.30,QX	1.75
U. S. Steel pfd.	New York	124⅛	124	123⅛	Fe.1, Fe.27, Q	1.75
Virginia I. C. & C.	New York	42	42	42	De.15, Ja.2	1.50
Virginia I.C.&C.pfd.	New York			79	De. 13, Ja. 2, Q	2.50
VANADIUM						
Vanadium Corp.	New York	30⅛	27⅛	29⅛	Jan., 1921	1.00
ARSENIC						
Western Utah Copper	N. Y. Curb	*20	*20	*20		
ASBESTOS						
Asbestos Corp.	Montreal	45⅛	44	44	Fe.1, Fe.15 Q	2.00
Asbestos Corp. pfd.	Montreal	88½	81	88.	Ja.2, Ja.15, Q	1.50
SULPHUR						
Freeport Texas	New York	11⅛	10⅛	10⅛	Nov., 1919	1.00
Texas Gulf	New York	106	102⅛	104⅛	De.1,De.15, QX	2.25
DIAMONDS						
De Beers Consol	New York			24⅛	Ja.6, Fe.2	0.95
PLATINUM						
So. Am. Gold & P.	N. Y. Curb	3⅛	3	3⅛		
MINING, SMELTING AND REFINING						
Amer. Metal	New York	51⅛	50⅛	52⅛	Fe.18, Mh.2 Q	0.75
Amer. Metal pfd.	New York	114⅛	114⅛	114⅛	Fe.19, Mh.2, Q	1.75
Amer. Sm. & Ref.	New York	105⅛	98⅛	105	Ja.16, Fe.2, Q	1.50
Amer.Sm.&Ref.pfd.	New York	110⅛	109	110	Fe.6, Mh.2 Q	1.75
Consol. M. & S.	Montreal	67⅛	63⅛	67	De.11, Ja.15	SA 0.75
Federated Metals	N. Y. Curb			37⅛		
Southwest Metals	N. Y. Curb	1⅛	1	1		
U. S. Sm. R. & M.	New York	36⅛	34⅛	35⅛	Jan., 1921	0.50
U.S. Sm. R.&M.pfd.	New York	45⅛	45⅛	45⅛	Ja.8, Ja.15	0.87½

* Cents per share. † Bid or asked. Q, Quarterly. SA, Semi-annually. M, Monthly. K, Irregular. I, Initial. X, Includes extra. The first date given is that of the closing of the books; the second that of the payment of the dividend.

Boston quotations courtesy Boston Stock Exchange; Toronto quotations those of the Standard Stock Exchange of Toronto, by courtesy of Arthur E. Moysey & Co.; Spokane, Pohlman Investment Co.; Salt Lake, Stock and Mining Exchange; Colorado Springs, Colorado Springs Stock Exchange.